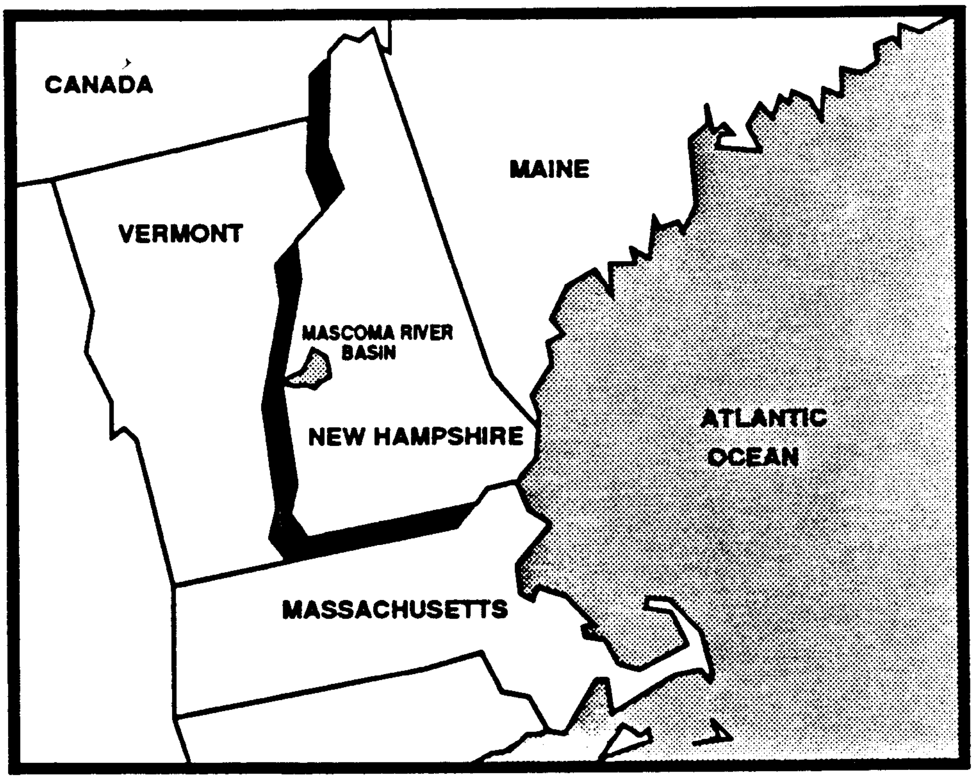
Water Resources Study
Mascoma River Basin, New Hampshire

Mascoma River Basin Study



February 1989

US Army Corps of Engineers
New England Division

WATER RESOURCES STUDY

MASCOMA RIVER BASIN

NEW HAMPSHIRE

FEBRUARY 1989

Department of Army
New England Division, Corps of Engineers
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Waltham, Massachusetts 02254-9149

SYLLABUS

This report was prepared for the Mascoma River Basin under authority derived from a Congressional resolution adopted by the Committee on Environment and Public Works of the United States Senate dated September 26, 1984.

This study investigated a variety of flood damage reduction measures to reduce recurring flood losses within the Mascoma River Basin. Measures investigated included structural and non-structural methods such as channel widening, channel diversions, dikes and walls, construction of potential reservoir sites, dam modifications, relocation of the existing homes and businesses and floodproofing and/or raising of the existing homes and businesses.

Study efforts have attempted to develop a comprehensive flood loss reduction plan that would be economical, publicly acceptable and compatible with other water related resources in the basin. However, it has been concluded that there are no Federally implementable flood damage reduction plans for the Mascoma River Basin. Some measures individual property owners can take to decrease their flood damage potential are discussed in this report. It is recommended that continued investigation under this authority be terminated.

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MASCOMA RIVER BASIN
STATE OF NEW HAMPSHIRE

A. Introduction

The Mascoma River, situated in west central New Hampshire, flows through the communities of Dorchester, Canaan, Enfield and Lebanon. A majority of the development within the basin is in Lebanon as are the major flood damage areas.

As a result of flooding that occurred during the June 1984 storm, the city of Lebanon requested assistance in developing a plan that would alleviate or reduce the risk of future flood losses. This reconnaissance level report presents the results of the investigations into various flood damage reduction measures throughout the Mascoma River Basin.

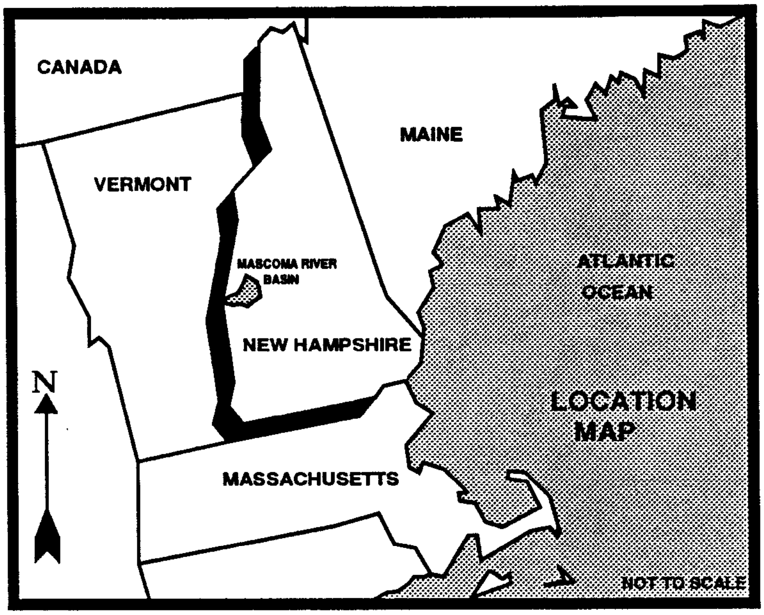
1. Study Authority

Authority for this report is derived from a Congressional resolution adopted by the Committee on Environment and Public Works of the United States Senate dated September 26, 1984. This resolution reads as follows:

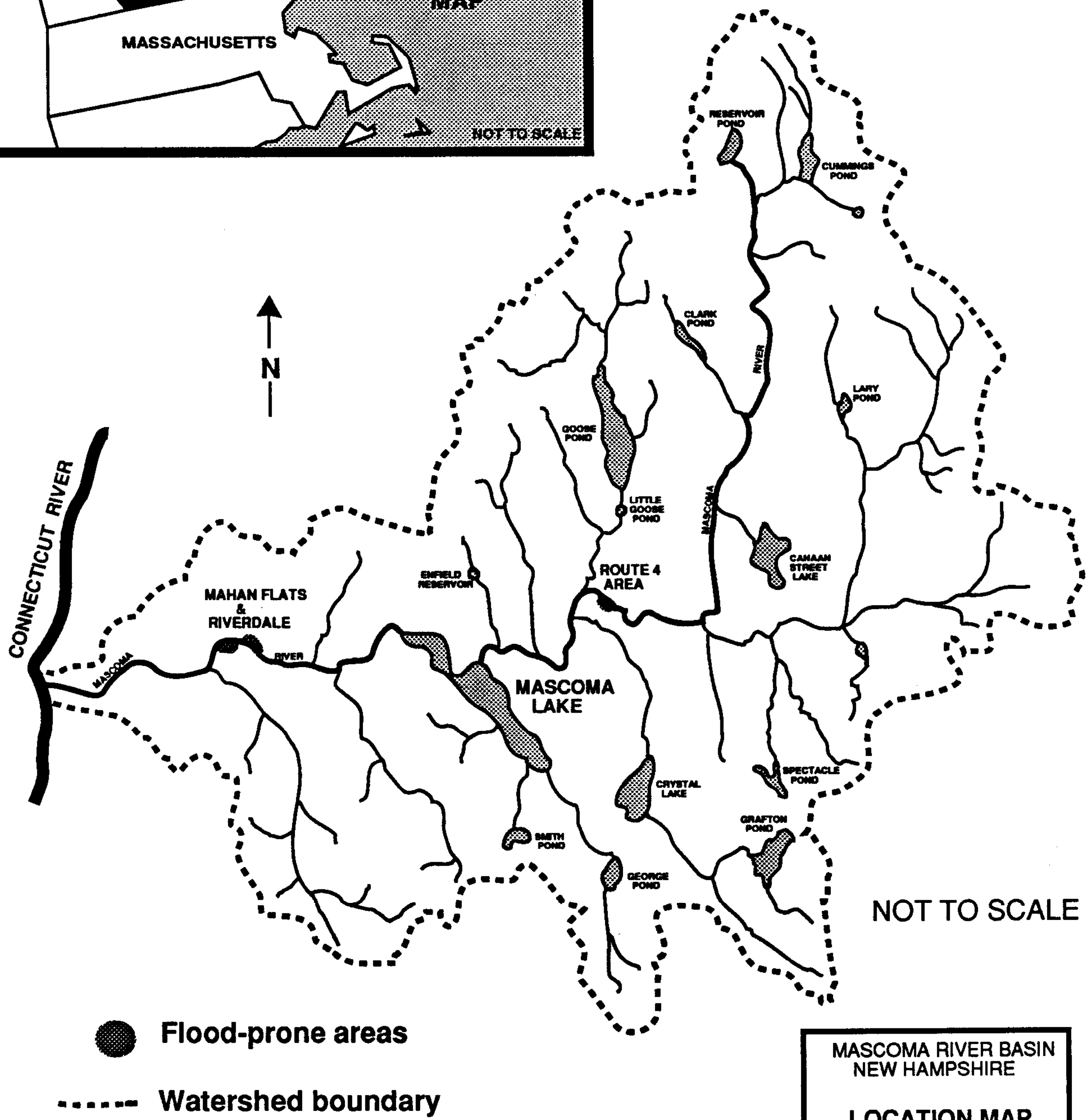
> That the Board of Engineers for Rivers and Harbors be, and is hereby, requested to review the reports on the Connecticut River, Massachusetts, New Hampshire, Vermont, and Connecticut, published as House Document Numbered 455, Seventy-fifth Congress, Second Session, and other reports, with a view to determining the advisability of modifying the existing project at this time, with particular reference to providing improvements for flood damage reduction and other allied purposes in the Mascoma River Sub-Basin, New Hampshire.

2. Study Area

The Mascoma River Basin is located in western New Hampshire and is a tributary of the Connecticut River watershed. The Mascoma River is approximately 35 miles long from its source to its confluence with the Connecticut River, in Lebanon, and has a drainage area of about 194 square miles. The study area includes the flood-prone residential and commercial properties in 'Mahan Flats' and Riverdale areas of Lebanon, New Hampshire and isolated flood-prone areas along Route 4 in Canaan, New Hampshire. The study area also included existing and potential reservoir and dam sites throughout the Mascoma River Basin (see Plate 1).



MASCOMA RIVER BASIN



MASCOMA RIVER BASIN
NEW HAMPSHIRE

LOCATION MAP

JANUARY 1989

PLATE 1

3. Study Objective

The primary objectives of this investigation were to expand on the findings of earlier studies, to update the existing hydrological conditions throughout the basin and to develop a viable plan for flood damage reduction throughout the Mascoma River Basin.

4. Prior Studies

Both upstream flood storage and localized flood protection have been studied in the Mascoma River Basin in the past as follows:

a. Reservoirs. A flood control dam and reservoir was authorized in 1938 by Congress. This dam, located at West Canaan, New Hampshire, would have controlled 80 square miles of the Mascoma River Basin drainage and would have stored 25,700 acre-feet of flood water. In 1941, the West Canaan Dam and Reservoir was reauthorized at a slightly larger scale, sized to hold 34,100 acre-feet.

In the Comprehensive Connecticut River Basin Study completed in the early 1970's, West Canaan Dam was considered an alternative to the Meadow Dam and Reservoir proposed for the Deerfield River in Massachusetts. Meadow Dam, due to its strategic location, had a greater impact upon the main stem flood stages in the urbanized lower basin reaches. At that time, although the West Canaan project was economically justified, there was little interest and the project was never constructed.

In the mid to late seventies, with the passage of Section 12 of Public Law 93-251, the West Canaan Dam and Reservoir project was reviewed for deauthorization and subsequently was deauthorized on August 5, 1977. There were no objections to this process at that time.

b. Local Protection. In 1957, the 'Mahan Flats' section of the city of Lebanon was considered for a small local flood protection project at the request of local interests. A project was formulated with a construction cost of $ 182,000 and had a benefit-to-cost ratio of 1.13. This project had a local cost of $ 49,000 which included lands and relocations. At the local level it involved removal of the Cummings Tannery Dam and the replacement of the Hanover Street Bridge. Lebanon opted not to participate and the project was not constructed.

In 1960, the city informed the Army Corps of Engineers that the Hanover Street Bridge was being replaced by them. They further requested consideration of the local flood protection project and asked for a plan that retained the dam, however, with crest gates for flood control purposes. This new plan, with the addition of nearly $ 100,000 for the crest gate structure, was not economically feasible.

In 1977, a damage survey was made of two localized areas in Lebanon. These included the 'Mahan Flats' and the Riverdale Parkway areas located upstream of the Cummings Tannery Dam. The annualized flood losses enumerated at that time were $ 53,000 and $11,300, respectively. A plan of protection, including channel improvements, was developed for each of the areas, which included the removal of the Cummings Tannery

Dam. Neither area was justified in 1977, as the benefit-to-cost ratios were 0.8 and 0.3, respectively. Local protection was again reviewed in 1981 with similiar results.

In 1985/86, the large regional shopping center in West Lebanon situated at the mouth of the Mascoma River and along the Connecticut River was considered for flood protection. The plan included dikes and walls but failed the economic feasibility test.

c. Hydroelectric. Hoskins Diversified Industies (HDI) had filed a hydroelectric application with the Federal Energy Regulatory Commission (FERC) on November 27, 1987. FERC issued an exemption from licensing on September 21, 1988. The dam is located approximately 1/2 mile downstream from the Hanover Street Bridge in Lebanon, NH. The proposed action would consist of : (1) an existing 285-foot long rock and concrete dam with two 123-foot long spillway sections, a spillway crest elevation of 502.7 feet mean sea level (msl), and 17-inch high flashboards separated by a waste-gate section; (2) an existing 5-acre reservoir; (3) an existing intake structure and pressure box; (4) an existing powerhouse that is part of the complex; (5) an existing 150-kilowatt (kW) generating unit that would be rehabilitated; (6) a proposed 175 kW generating unit; (7) an existing 100-foot long tailrace that would be enlarged; (8) a proposed 400-foot long transmission line; and (9) appurtenant facilities. The project would be operated as a run-of-river facility. The applicant estimates that the annual energy production would be 1,300,000 kW.

d. Other Studies. Within the Mascoma River Basin, a number of Federal, State, regional and local agencies have engaged in water resource investigations. The extensive data developed in these prior studies were evaluated and utilized as support in the preparation of this study. These studies include:

The River's Reach: A Unified Program for Flood Plain Management in the Connecticut River Basin. The River's Reach was published by the New England River Basins Commission in December 1976. Mascoma River Basin was included as a tributary to the Connecticut River Basin.

Flood Insurance Studies: Flood Insurance Studies have been prepared for the towns of Lebanon (May 1987), Enfield (May 1988), and Canaan (May 1988) by the Federal Emergency Management Agency.

Climatological Data Annual Summary, New England, Volume 96, Number 13: Climatological Data Annual Summary was published by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Service in 1984.

Flood Plain Information, Connecticut-White-Mascoma Rivers, Thetford, Norwich, Hartford and Hartland, Vermont; Lyme, Hanover, Lebanon and Plainsfield, New Hampshire: Flood Plain Information Study was published by the U.S. Army Corps of Engineers in May 1972. The report related the flood situation along the Connecticut, White and Mascoma Rivers.

NENYIAC Report: A report by the New England-New York Inter-Agency Committee (NENYIAC) was completed in 1955. It entailed a comprehensive study of overall water resources problems and opportunities in the Connecticut River watershed, and identified potential management plans.

B. Background

This section presents the hydrologic and environmental information and analysis of the Mascoma River. Included are sections on basin description, streamflow, climatology, flood history, and analysis of recent floods and environmental setting. The purpose of this evaluation is to provide background information for use in this Mascoma River Basin Study.

1. Basin Description

The Mascoma River Basin lies wholly in the western part of New Hampshire. The towns of Dorchester, Canaan, Enfield and Lebanon are within the basin's boundaries. The Mascoma River originates at the outlet of Reservoir Pond in Dorchester and flows southerly into Canaan, then westerly through Enfield and Lebanon to its confluence with the Connecticut River. On its course, the Mascoma River flows through Mascoma Lake, a 1,200-acre body of water in Enfield. The Mascoma River is approximately 35 miles long from its source to its confluence with the Connecticut River and has a drainage area of about 194 square miles. The largest tributary of the Mascoma River is the Indian River with a drainage area of about 45 square miles (see Plate 2).

On its course, the Mascoma River flows through Mascoma Lake, a 1,200-acre body of water in Enfield. The lake is controlled by a dam consisting of 3 different sections: a rock-filled timber crib, 156 feet long; a concrete abutment, containing sluice gates 27 feet long; and two earth embankments at each end, approximately 392 feet long. The dam was built in 1917 as a water supply and recreation reservoir. The dam is presently owned and operated by the New Hampshire Water Resource Division.

The topography of the basin is marked by several small mountains with elevations ranging from about 3,200 feet above mean sea level at the northerly end of the basin to about 324 feet above mean sea level at the confluence with the Connecticut River. The Mascoma River has a total fall in elevation of about 1,017 feet. From Reservoir Pond to Canaan Center, the average slope is about 39 feet per mile and from Canaan Center to Mascoma Lake, the average slope is about 13 feet per mile. From Mascoma Lake to the confluence, the average slope is about 42 feet per mile, with the greatest drop in this reach in the city of Lebanon.

The Mascoma River watershed is subject to excessive rainfall and fairly large snow depths. The river drains the steep slopes of the small mountains located within the basin. However, the flat gradients just at the foot of the mountains, together with the swamps and ponds, tend to delay the progress of floods from the upper half of the basin. Most of the water bodies in the Mascoma River basin are operated for storage for power, flood control and recreation by the New Hampshire Water Resource Board.

2. Streamflow

The U.S. Geological Survey maintains a stream gaging station on the Mascoma River in Lebanon, New Hampshire. The station is located 1,000 feet downstream of the Mascoma

Lake Dam, and has a drainage area of about 153 square miles. The station has been maintained since August 1923 and has an average annual flow of 216 cubic feet per second (cfs) which is equivalent to 19.2 inches of runoff or approximately 50 percent of average annual precipitation. Runoff rates recorded at this location are effected by storage and regulation of Mascoma Lake. Estimated mean, maximum and minimum monthly runoff rates for the Mascoma River are shown in Table 1.

TABLE 1

MASCOMA RIVER RUNOFF RATES
(Drainage area = 153.0 square miles)
(Years of Record - from 1923 to 1985)

	Mean		Maximum		Minimum	
	Inches	CFS	Inches	CFS	Inches	CFS
January	1.18	156	2.77	368	0.29	39
February	1.20	177	3.74	550	0.27	39
March	2.39	317	9.21	1,222	0.49	65
April	4.68	642	9.76	1,338	1.67	229
May	2.68	355	5.75	763	0.59	78
June	1.35	185	3.60	493	0.44	60
July	0.90	119	4.96	658	0.28	3
August	0.72	96	2.95	392	0.19	25
September	0.69	94	4.31	591	0.23	31
October	0.90	120	3.47	461	0.26	35
November	1.18	162	4.08	560	0.26	36
December	1.35	179	4.57	607	0.35	46
Annual	19.22	216	31.94	359	7.47	84

3. Climatology

a. General. The Mascoma River Basin lies within the southern New England region. This region is semihumid with an average annual precipitation of about 36 inches, and has a variable climate characterized by frequent but generally short periods of heavy precipitation. It lies in the path of the "prevailing westerlies" and is exposed to cyclonic disturbances that cross the country from the west and southwest. This region is also exposed to coastal storms that travel up the Atlantic seaboard in the form of hurricanes of tropical origin. Spring melt of the winter snows throughout most of the basin occurs generally in late March and early April.

b. Temperature. The mean annual temperature of the basin is about 45 degrees Fahrenheit. Extremes in temperature range from highs in excess of 90 degrees in the summer to subzero lows in the winter. Mean temperatures at Hanover, New Hampshire located adjacent to the Mascoma River Basin are shown in Table 2.

TABLE 2

MONTHLY TEMPERATURES
HANOVER, NEW HAMPSHIRE
(98 years of Record)

Month	Mean Temperature (Degrees Fahrenheit)
January	17.9
February	19.7
March	29.9
April	42.9
May	55.1
June	64.1
July	69.0
August	66.6
September	59.1
October	47.7
November	35.5
December	22.4
Mean Annual Temperature	44.7

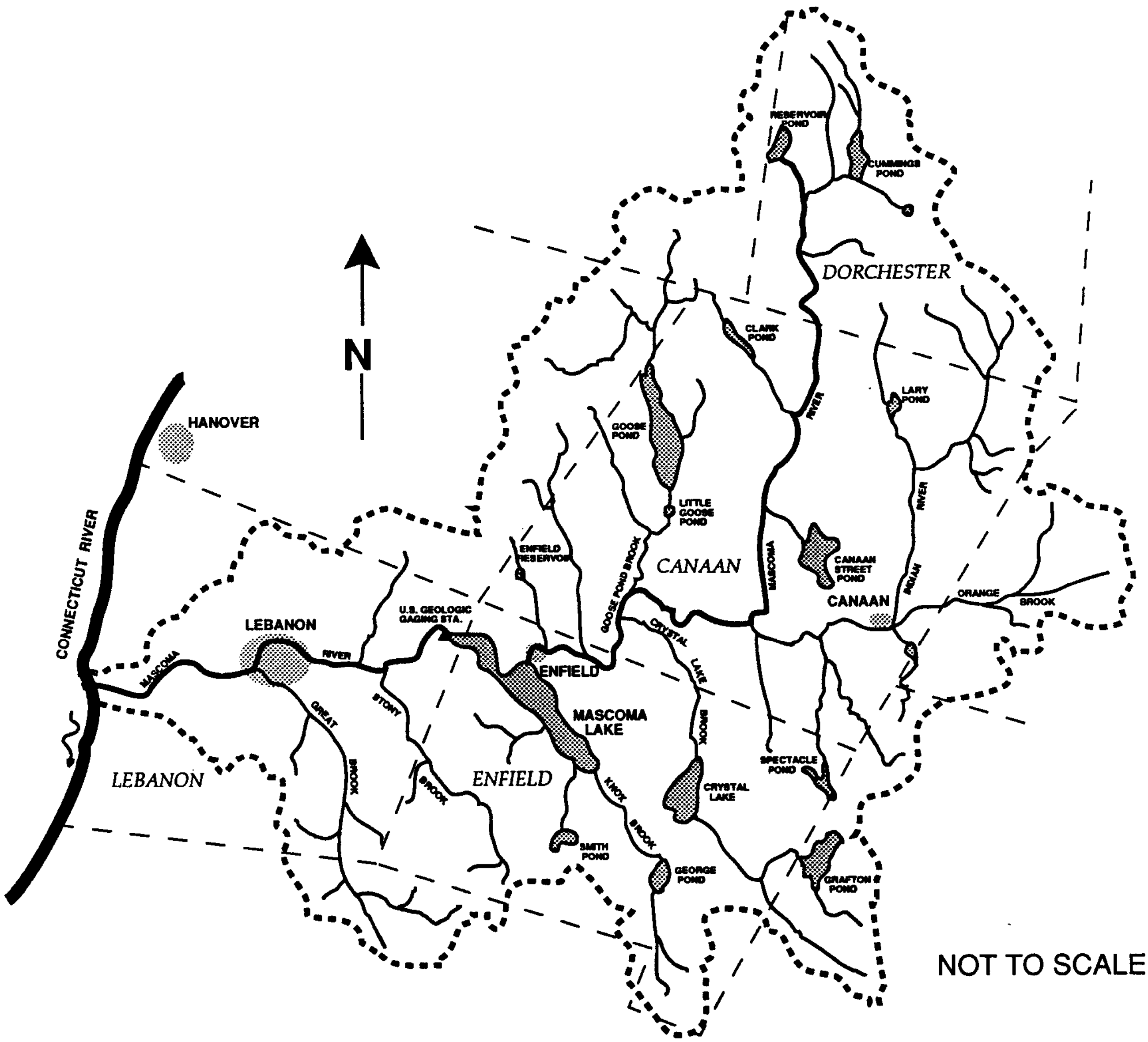
c. <u>Precipitation</u>. The mean annual precipitation of the watershed is about 36 inches. The greatest annual precipitation recorded at Hanover, New Hampshire was over 50 inches in 1983. Table 3 summarizes mean, maximum and minimum precipitation as recorded at Hanover.

TABLE 3

MONTHLY PRECIPITATION
HANOVER, NEW HAMPSHIRE
(140 Years of Recorded)

	Mean	Maximum	Minimum
January	2.67	6.76	0.31
February	2.36	7.67	0.27
March	2.63	8.25	0.20
April	2.73	6.26	0.07
May	3.1	7.37	0.55
June	3.35	7.42	0.43
July	3.51	9.69	0.51
August	3.42	10.19	0.12
September	3.22	8.88	0.27
October	3.05	9.29	0.12
November	2.88	8.67	0.55
December	2.74	7.69	0.61
Annual	35.73	55.85	22.6

MASCOMA RIVER BASIN



Legend

City Limits

— – Town Lines

▪ ▪ ▪ ▪ Watershed Boundaries

MASCOMA RIVER BASIN
NEW HAMPSHIRE

BASIN MAP

JANUARY 1989

PLATE 2

d. Snowfall. Average annual snowfall for 58 years of record is 73.4 inches. Snowfall values are shown in Table 4.

TABLE 4

MEAN MONTHLY SNOWFALL
HANOVER, NEW HAMPSHIRE
(94 Years of Record)

	Inches
January	18.1
February	18.0
March	12.5
April	4.3
October	0.2
November	5.5
December	14.6
Annual	73.4

4. FLOOD HISTORY

a. General. There are historical references to floods on the Mascoma River dating back when the area was settled, about 1750; but there is little information available to the magnitude of floods prior to the early 1900's. The March 1936 event is the greatest recorded flood on the Mascoma River. The seven greatest floods that have occurred since August 1923 are shown in order of magnitude in Table 5.

TABLE 5

GREATEST RECORDED FLOODS
MASCOMA RIVER AT LEBANON, N.H.
Zero of Gage = 740.0 feet NGVD
(Drainage area = 153 square miles)

Date of Crest	Elevation at Gage (feet NGVD)	Peak Discharge (cfs)
March 19, 1936	747.5	5,840
March 27, 1953	746.0	4,880
September 22, 1938	746.9	4,400
July 1, 1973	745.8	4,260
June 1, 1984	745.7	4,200
April 19, 1933	746.7	3,630
April 1, 1987	745.4	3,600

The following are descriptions of two large floods which have occurred in the Mascoma River Basin, one with rainfall on a heavy snow cover and the other with only heavy rain.

b. March 1936 - The flood of March 1936 was the result of several storm centers passing over the northeastern part of the country between March 9 and 22. The total precipitation for this period ranged from four inches in eastern Massachusetts up to 16 inches in north-central New Hampshire. The first precipitation fall on a snow cover which had a water content ranging from five to ten inches in northern New England. During the March 9-22 period the precipitation at Hanover, New Hampshire totalled 4.6 inches. The ground had frozen early in the winter, and the rain which fell during the period was accompanied by unseasonably high temperatures. These factors combined to give many New England rivers their greatest flood peaks to date. At the Mascoma River gage, the river rose to elevation 745.5 feet NGVD on March 14, dropped back to elevation 744.5 feet NGVD on the 16th, only to crest at elevation 747.5 feet NGVD on March 19, before receding to elevation 744.5 feet NGVD on the 25th. Stage comparisons indicate that the flood level at the Hanover Street Bridge, located immediately downstream of the Mahan Flats damage area, crested at about elevation 582 feet NGVD. In general, the river rose three to five feet above flood stage.

c. May/June 1984 - During the last week of May a large slow moving storm system passed through New England bringing rainfall on Memorial Day that continued for approximately a week. Precipitation amounts varied from eight to nine inches in Massachusetts, Connecticut, and Rhode Island to about five to seven inches in New Hampshire and Vermont.

This was a major flood event along the main stem of the Connecticut River, in southern Massachusetts and Connecticut. It has only been exceeded by the September 1938 and the March 1936 floods.

At the USGS gage below Mascoma Lake, the river rose to about elevation 745.2 feet NGVD on June 1 and then receded to about elevation 742.0 feet NGVD on June 7. Total rainfall recorded at Hanover, N.H. was over 6.0 inches for the period of May 27 through June 2. Additional information on the hydrology throughout the basin is in the attached Hydrologic Report. Plate 3 includes photographs of some of the more recent flooding problems.

5. RECENT FLOODS

March/April 1987. This most recent flood began on March 31 when the New England region began experiencing heavy rainfall. However, the Mascoma River Basin experienced only about two to three inches of rain for the March 31 - April 8 period. Because of the relatively small amount of rain in the basin and the modifying effects of Mascoma Lake, the Mascoma River did not experience any significant flooding.

At the USGS gage, the river rose to elevation 745.2 feet NGVD on April 1, receded on April 4 to elevation 743.4 feet NGVD and then rose to elevation 744.4 feet NGVD on April 7, before receding to elevation 743.2 feet NGVD on April 10. A corresponding flood level of about 572.0 feet NGVD was attained at the Hanover Street Bridge. Total rainfall recorded at Hanover, N.H. was 2.96 inches over the period of March 31 through April 8.

6. ENVIRONMENTAL SETTING

The Mascoma River, a tributary of the Connecticut River, is located in west-central New Hampshire and drains a basin of approximately 194 square miles. The headwaters of the watershed are formed by a series of small lakes and ponds located in the towns of Dorchester, Canaan and Enfield, New Hampshire. These ponds and lakes drain by small streams into the 1,200 acre Mascoma Lake. From the outlet of the lake, Mascoma River flows 10.2 miles through the city of Lebanon to its confluence with the Connecticut River. Most of the water bodies in the Mascoma River basin are operated for storage for power, flood control and recreation by the New Hampshire Water Resource Board.

a. Topography and Geology

The watershed consists of upland hills and peaks in the northern and eastern portions of the watershed, then more gently rolling hills in the western portion near the Connecticut River. Elevations in the watershed range from 3,200 feet NGVD in the headwaters to 324 feet NGVD at the confluence with the Connecticut River. In the project area, elevations range from 800 feet msl at West Canaan to 580 feet NGVD at 'Mahan Flats' in Lebanon, NH.

The project area is underlain by bedrock which is generally Paleozoic in age. These rocks consist of Ordovician, Silurian, and Devonian sediments and Devonian and Carboniferous igneous rocks. The original sedimentary rocks have been altered to schist, quartzite, slate, gneiss and other metamorphic rocks.

The surficial geology of the area is primarily glacial till consisting of a mixture of clay, silt, sand, gravel, cobbles and boulders. Overlying the till are stratified materials laid down in glacial lakes and streams. These deposits are composed of bedded sands and gravels or clay and silt.

b. Water Quality

From just downstream of the outlet of Mascoma Lake to its confluence with the Connecticut River, the Mascoma River has been subjected to pollution from many sources in the areas of Lebanon and West Lebanon (State of New Hampshire, 1982). These sources include primarily domestic and municipal sewage outfalls. The City of Lebanon's wastewater treatment plant is located at the mouth of the Mascoma River.

The legislative classification by the New Hampshire Water Supply and Pollution Control Commission (1988) for the Mascoma River in the project area is as follows:

Class A - from the Mascoma Lake outlet to the Lebanon Wasteworks Intake

Class C - from the Wasteworks downstream to the mouth

Class A waters are of the highest quality, with no discharge of any sewage or wastes. They are potentially acceptable for water supply uses after disinfection.

Class C waters are of the third highest quality and are partially acceptable for recreational boating, fishing, and industrial supply following adequate treatment.

c. Natural Resources

A wide variety of fish and wildlife resources can be found in the Mascoma River watershed. Most of the watershed is covered by a forest zone characterized by northern hardwoods, such as sugar maple, red maple, yellow birch, beech, red oak and ash. Hemlock and white pine are also closely associated with the hardwood species. In the upper reaches of the basin, forest species consist mainly of red, white and black spruces and balsam fir. Timber harvesting, forest fires and varying soil conditions have altered some of the forest patterns in the region.

The edge effect created by riparian vegetation, open grassy areas, forest and open and flowing water provides excellent habitat for many species of birds and mammals. Birds that frequent the basin and the project area include: red-tailed hawk, broad-winged hawk, downy woodpecker, pileated woodpecker, great horned owl, crows, belted kingfisher, red-winged blackbird, green-backed heron, great blue heron, spotted sandpiper, black-capped chickadee, mallard ducks, wood ducks, mergansers, ruffed grouse and woodcock.

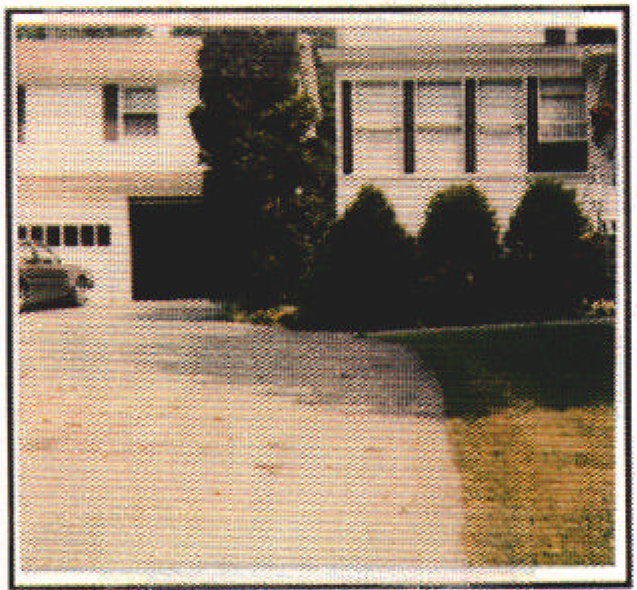
Wildlife species common to the basin include: raccoon, skunk, beaver, porcupine, muskrat, mink, red fox, New England cottontail, whitetailed deer, shrews, voles, mice, red and grey squirrels, and long and short-tailed weasel.

Pool-riffle habitat with gravel/cobble substrate and low gradient areas with sandy substrate provide excellent fisheries habitat in the basin and project area. Brook, brown, and rainbow trout are stocked annually by the New Hampshire Fish and Game Department. In 1987, a total of 9248 trout (6940 brook, 1608 brown and 700 rainbow) were stocked in the Lebanon-Enfield area (USFWS, 1988). Other species that occur in the Mascoma River, influenced by the presence of Mascoma Lake, include: smallmouth bass, rock bass, yellow perch, brown bullhead, common sucker, eastern and common shiners, creek chub, fall fish, eastern black and long-nosed dace, eastern johnny darter, and slimy sculpin. The river offers easy fishing access in many places throughout the basin.

The Connecticut River Atlantic Salmon Restoration Program will in time affect fishery management in the Mascoma River. This program is a Federal and State cooperative effort to restore and maintain Atlantic salmon in the Connecticut River basin to provide for both natural spawning populations and a sport fishery. The Mascoma River has not been designated as one of the initial ten high priority rivers for restoration. It is presently in a deferred status. Once the long-term program goal of full watershed utilization is realized, fish passage will likely be required at the dams along the Mascoma River to allow the reintroduction of anadromous species into the basin (USFWS, 1988).

d. Threatened, Rare and Endangered Species

According to the U.S. Fish and Wildlife Service by letter dated August 22, 1988, there are no Federally listed or proposed endangered or threatened species in the Mascoma River Basin (see Enclosure).



23 Thompson Street, Mahan Flats, Lebanon, NH
Photo taken on July 1988 during normal flow.

23 Thompson Street, Mahan Flats, Lebanon, NH
Photo taken during July 1973 Flood Event.

23 Thompson Street, Mahan Flats, Lebanon, NH
Photo taken on July 1988 during normal flow.

23 Thompson Street, Mahan Flats, Lebanon, NH
Photo taken during July 1973 Flood Event.

Mascoma Lake Dam
Photo taken on July 1988 during normal flow.

Mascoma Lake Dam
Photo taken during June 1984 Flood Event.

PLATE 3

e. Historic and Archaeological Resources

Prehistoric Period (11,000 years before present [B.P.] to c. 1600 A.D.)

There are no recorded archaeological sites dating from the prehistoric period within the project study area. However, given the great intensity of prehistoric occupation that has been detected along the Connecticut River and many of her tributaries, we would expect that the Mascoma River Valley was exploited by Amerindian groups for at least the last 8-10,000 years. The river would probably have been used as a major highway, with streams and side valleys being side avenues to access the uplands. Sites are very likely to be located along the banks of the river, especially at stream junctions.

Any structural solutions to flooding, such as dikes, walls or rip rapping could affect as yet undiscovered archaeological sites. Professional archaeological surveys would be required to document disturbed and undisturbed areas before such structures were constructed. Non-structural solutions, such as floodproofing buildings, or creating flood-warning systems, would be unlikely to affect undisturbed prehistoric archaeological sites.

Historic Period - Lebanon

The Mascoma River has provided water power for many mills and businesses since the settlement of Lebanon in 1763. Lebanon had the advantage of the Connecticut River as a reliable transportation route to the markets of Hartford and New York. Therefore, the town prospered as a small commercial center. While development in the nineteenth and twentieth centuries may have destroyed many of these mills and factories, some may be present as historical archaeological sites. Many dams still remain on the river, many still in good repair and operation.

In the specific study area encompassing Riverdale and Mahan Flats, preliminary historic research suggests that most structures currently under study were built later than 1860. Only one house, in the Riverdale section appears to be on the 1860 map. Specific, detailed deed research would be required if structural alternatives are pursued to confirm this preliminary finding. Flood-proofing of structures , or house raising, would have to be reviewed if any structures were considered historic by the New Hampshire State Historic Preservation Office. (For further information, refer to Appendix).

C. Problem Identification

1. Without Project Conditions

The following discussion focuses on the most probable future conditions of the Mascoma River Basin assuming that no new Federally-sponsored water resource projects are developed in the area. This analysis is intended to identify problems of the study area and to serve as a baseline against which the expected impacts of water resources can be judged.

a. Existing and Future Population and Economy. The population trend for the State of New Hampshire has increased and is expected to continue in the future. The population in the Mascoma River Basin has been increasing slightly for the past 20 years. This is due to the completion of Interstate Route 89 through Lebanon which has attracted industry and commerce. Moderately dense residential, commercial and light industrial development is concentrated along the Mascoma River in the vicinity of Lebanon center and adjacent to the Connecticut River in West Lebanon.

b. Future Flood Losses. Geographically, flood losses are concentrated in 3 distinct damage centers in the basin, namely Mahan Flats and Riverdale in Lebanon and an area of Rt. 4 in Canaan (see Plate 4). A flood damage survey was performed in these damage centers during April 1988 by a flood damage evaluator from the New England Division. Both physical and non-physical losses were estimated. Also, the cost of emergency services and damages to transportation, communication and utility systems were obtained where possible.

c. Recurring Losses. Recurring losses are those potential flood related losses which are expected to occur at various stages of flooding under present day development conditions. As the final output of the flood damage survey process, recurring losses are expressed as an array of dollar losses, in one foot increments, from the start of damage to the elevation of the rare (500 year) event. The number and type of properties, in each of the 3 damage center, for which recurring losses wre estimated is as shown in Table 6.

TABLE 6

FLOOD PRONE PROPERTIES

	Mahan Flats	Riverdale	Canaan
Commercial	9	1	1
Residential	26	58	3
Public	3	-	-
TOTAL	38	59	4

Total recurring losses for selected flooding events in the 3 damage centers under investigation are found in Table 7.

TABLE 7

RECURRING LOSSES - BY EVENT

Location	10 Year	50 Year	100 Year	500 Year
Mahan Flats	$54,700	$217,600	$306,200	$745,700
Riverdale	106,700	240,100	305,300	691,300
Canaan	130,400	198,600	218,600	230,600
TOTAL	$291,800	$656,300	$830,100	$1,667,600

Annual Losses. The purpose of estimating annual losses is to measure the severity of potential flooding on an "expected annual basis" in each damage center. The effectiveness of each alternative flood reduction plan is measured by the extent to which it reduces annual losses. Annual losses in the 3 damage centers are as follows: Mahan Flats $26,300, Riverdale $37,900, and Canaan $47,200 for a total of $111,400.

Canaan has the highest annual losses with the fewest structures. This is due to the fact that a general store along Route 4 in Canaan is located in the 10-year floodplain. According to State law, if any portion of the store gets flooded, all the foods in the store must be destroyed. This causes the damages for the store to be very high.

The flood threat thoughout the remainder of the basin is minor. Flooding in Enfield and Canaan consists primarily of roads with scattered structure. Providing local flood protection to these areas is not feasible, however they are included in the evaluation of basin wide and reservoir plans.

2. Problems and Opportunities

The problem and opportunities discussed in this section, and the objectives statements which follow, have been identified through an understanding of the existing characteristics of the study area and through interaction with other Federal, State and local agencies.

a. Flooding Problem. Recurring flood events along the Mascoma River have resulted in property damages, loss of utilities, and the need for residents to evacuate their homes until access and services are safely restored. Average annual flood losses for the Mahan Flats, Riverdale and Canaan areas are estimated at $111,400.

b. Socio-Economic Opportunity. The city of Lebanon seeks to reduce potential flooding problems within the Mahan Flats, Riverdale and Canaan areas.

c. Problem and Opportunity Statements. Based on the above summary of problems and opportunities in the study area, the following objectives were developed to guide the formulation of a flood damage reduction project within the Mahan Flats and Riverdale areas of Lebanon, and to serve as a standard against which the achievements of the alternative plans could be assessed.

(1) Reduce the flood hazard and associated urban flood damages along the Mascoma River within the Mahan Flats, Riverdale and Canaan areas.

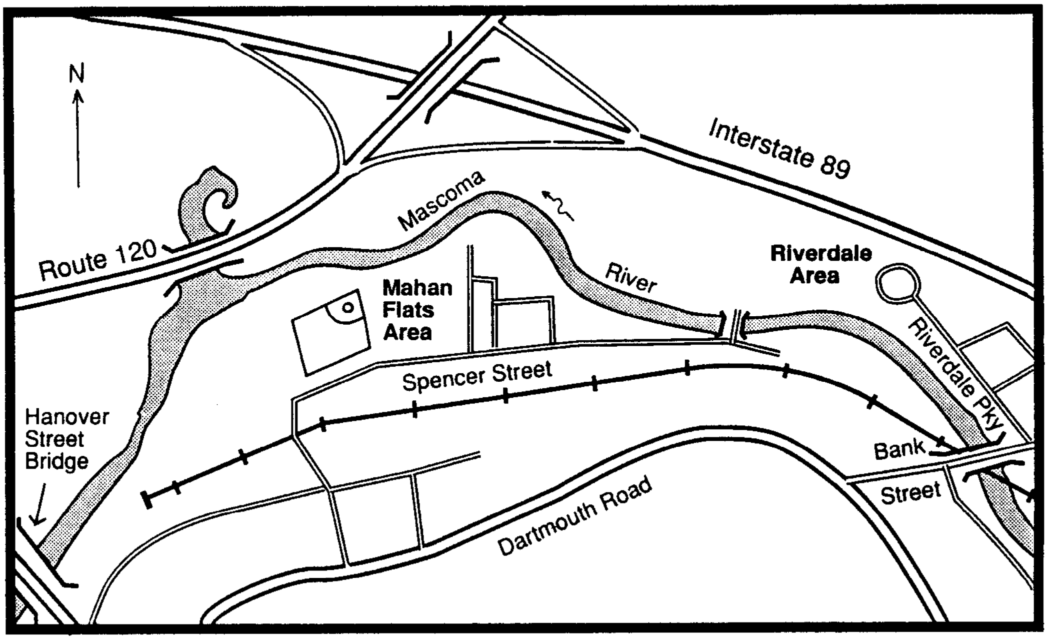
d. Planning Concerns. The following concerns have been identified during the course of the study and should be considered when developing alternatives.

(1) Maintain and enhance, where possible, recreational opportunities throughout the basin.

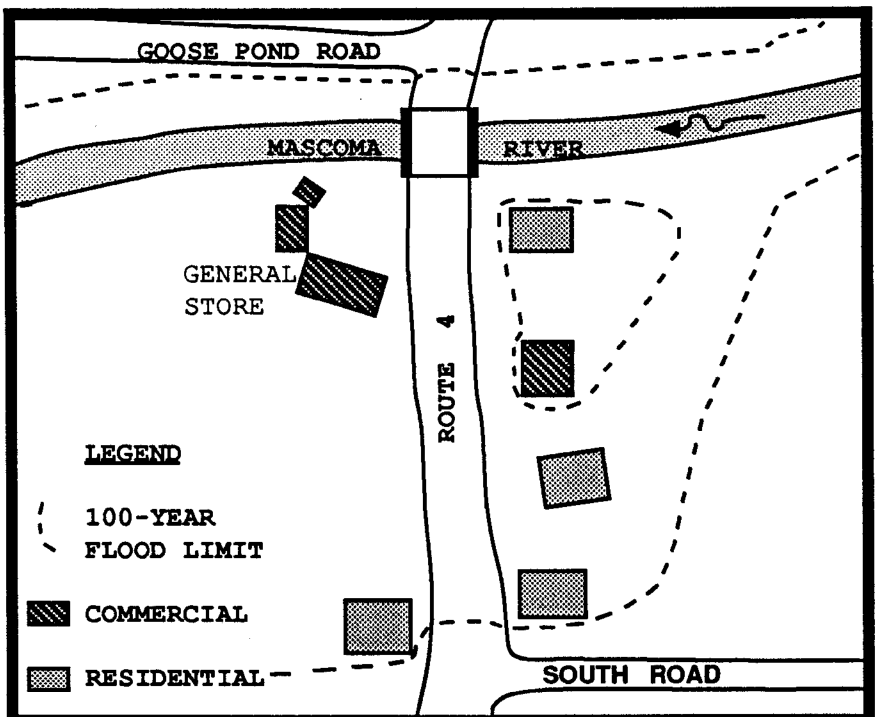
(2) Maintain and protect the historical and cultural attributes of any site discovered within the project boundaries that has the potential to be included in or eligible for the National or State Register of Historical Places.

(3) Maintain existing open space areas and environmental habitat throughout the basin.

(4) Pursue the coordination efforts with other responsible agencies to further address the problems and opportunities of the study area to effect a complete and adequate solution to the flooding problems.



'MAHAN FLATS' AND RIVERDALE, LEBANON, NH



ROUTE 4, CANAAN, NH

MASCOMA RIVER BASIN

DAMAGE AREAS INVESTIGATED

PLATE 4

D. Plan Formulation

This study for the Mascoma River Basin identified and investigated the flood control merits of several alternative plans and evaluated their engineering and economic feasibility with respect to local flood protection. This section describes alternative plans considered and the evaluation process used for their screening. A preliminary environmental evaluation of each of the alternatives considered is included in the Environmental Considerations Report.

1. Screening of Alternatives

a) Flood Protection Measures. Flood protection measures fall into two basic categories: structural and nonstructural. Structural measures are those that reduce overbank flooding, while nonstructural measures reduce or mitigate the damages caused by flooding. The two general categories of flood protection measures are shown in Table 8 and described in further detail in this section.

TABLE 8

ALTERNATIVE FLOOD DAMAGE REDUCTION MEASURES

I. Structural - Measures to Reduce Flooding
- A. Reduce Flooding Prior to Reaching Critical Damage Area
  1. Reservoirs
  2. Diversions
  3. Land Treatment
- B. Reduce Flooding at Critical Damage Area
  1. Levees and Floodwalls
  2. Channel Modifications

II. Nonstructural - Measures to Reduce or Mitigate Flood Damage
- A. Reduce Actual Damages
  1. Floodproofing
  2. Relocation
  3. Land Use Regulations and Zoning
  4. Flood Warning and Emergency Evacuation
  5. Regulation of the Existing Reservoirs
- B. Mitigate Damages
  1. Flood Insurance

b) Plan Formulation Rationale. The plan formulation process involves the development and evaluation of management measures as described in Table 6. Each measure was assessed in terms of social, environmental and economic impacts along with public acceptance. Both structural and nonstructural plans were evaluated for economic justification. Annual costs and benefits reflect the October 1988 level of prices. Costs amortized over a 50 year period of analysis using an interest rate of 8 7/8%. Benefits are estimated for diversion plans by calculating annual losses prevented up to the design level of protection. Benefits for dikes and walls include annual losses prevented up to the level of protection (elevation) plus expected losses in the lower half of the freeboard range. For channel modifications, annual losses are calculated for the natural and modified channel conditions. The difference in the two sets of losses is the benefits to the modification plan. Benefits for the raising of first floors are estimated by comparing annual losses to each structure with the first floor at the existing elevation versus the losses with the first floor raised one foot above the 100 year flood level. Benefits are the difference in annual losses. Relocation plans seek to remove the damage potential from the floodplain by relocating the inhabitants and their personal property. Benefits for relocation are specialized and discussed at length further in this report. Alternatives that did not address the problems and opportunities of the study area were eliminated.

1.) **Reservoirs.**

A common method of reducing peak flood flows is to temporarily store flows in an upstream area away from the damage areas, and gradually release these flows in a controlled and non-damaging fashion.

As a possible basin-wide solution, a review of the watershed was undertaken to locate possible flood control reservoir sites. The Mascoma River has a total drainage area of about 194 square miles. Any potential flood control reservoir must be able to control sufficient drainage area to significantly reduce downstream peak floodflows. As stated previously, a prominent feature in the watershed is Mascoma Lake which has a drainage area of 153 square miles or about 80 percent of the total Mascoma River watershed. The lake formerly provided water for downstream hydropower plants but is now used mostly for recreation. Other existing reservoirs above Mascoma Lake, namely Goose Pond, Clark Pond, Crystal Lake (Canaan Center), and Crystal Lake (Enfield) have a total of approximately 60 square miles of drainage area. These reservoirs all have extensive shorefront development and would not be effective as flood control reservoirs.

As part of the New England - New York Inter-Agency Committee (NENYIAC) studies on flood control reservoir (West Canaan) was located within the Mascoma River watershed. This site, with a drainage area of 80 square miles, is situated on the Mascoma River, 19.5 miles above its confluence with the Connecticut River, and about 1 mile upstream from West Canaan, New Hampshire. Development of the site for flood control purposes would require considerable land taking (1600 acres) and would reduce peak discharges at Lebanon about 50 percent. At the time of the NENYIAC report it was concluded that development of this site for flood control would be uneconomical due to necessary highway and railroad relocations.

The only remaining tributaries with significant drainage areas are Indian River and Orange Brook (total drainage area = 34.7 square miles) and the Mascoma River above

Canaan Center (total drainage area = 23 square miles). Indian River and Orange Brook are located upstream of Canaan and to provide a reasonable amount of flood control storage (equivalent to six inches of runoff from their upstream watersheds) a dam would have to be constructed at their confluence. A dam approximately 35 feet high and 1500 feet in length would have to be constructed at the confluence of the two streams (also two upstream 20-25 foot high dikes would be needed to contain the reservoir). Construction of this dam and dikes would require a total land area of about 280 acres. It is estimated that this flood control reservoir would reduce peak discharge at Lebanon about 20 percent. The relocation of several roads and the taking of some residences would also be required. It is estimated that flood control reservoirs at Indian/Orange Brook and Mascoma River at Canaan would reduce stages at Lebanon for a recurrence of the 1984 flood about 0.5 feet and 0.3 feet, respectively. These reservoirs are expected to have high real estate and construction costs, as well as potential adverse environmental impacts and are viewed as unfeasible.

2.) **Diversions.**

Diversions are used to divert the flood flows from upstream of a damage area to a point downstream of the area. The flood flows can be conveyed through pipes, tunnels or overflow channels. A tunnel diversion, designed to convey a 100-year floodflow, from upstream of the Riverdale area to downstream of Mahan Flats would be about 3800 feet long and cost about $10,500,000 (see Plate 5). The tunnel diversion would eliminate all damages up to and including a 100-year event. Benefits would be $33,300 for Riverdale and $20,500 for Mahan Flats for a total of $53,800. With an annual cost of $945,000 the benefit/cost ratio is 0.06 to 1 and the plan is not economically justified. Because of the flood plain , extensive development in the open channel overflow type diversion was not possible. A diversion channel or tunnel was not considered a practical solution for the damage area along Route 4 in Canaan. There is only 1 business and 3 homes with a potential for damage and the resulting benefit could not support the cost of a diversion. Therefore, diversions were eliminated from further study.

3.) **Land Treatment.**

Although adopted primarily to further good agricultural and forestry practices, land treatment and watershed management measures have beneficial effects on flood conditions. Modifying or preserving vegetative cover conserves water by increasing infiltration and reducing surface runoff. The degree to which flood discharges may be influenced varies with the watershed, the characteristics of flood-producing storms and antecedent moisture conditions. However, accelerated runoff is not a significant contributing factor to the severity of flooding in the basin, due to the primarily rural nature of the basin. Thus land treatment measures would do little to control flooding in the basin and were ruled out from futher study.

4.) **Levees and Floodwalls.**

Levees (earth dikes) and floodwalls are generally used to prevent floodwaters from entering a damage-prone area. They can be constructed to protect an individual structure or a group of structures against damage, and in more comprehensive plans they can be used to confine floodflows to a particular channel.

The study evaluated a proposal for the construction of an earth dike at the Mahan Flats area. The alignment for the earth dike can be seen on Plate 6. The earth dike was designed to prevent damages for a 100-year flood event along the Mascoma River. The dike would be about 2800 feet long with a maximum height of 9 feet above the ground. The total cost of an earth dike in the Mahan Flats area was estimated to be just over $1,000,000 with an annual cost of about $90,000. Benefits are annual losses prevented up to the 100 year flood elevation (578 feet NGVD) plus 50 percent of the 3 feet of freeboard for a total height of 579.5 feet NGVD. Benefits total $23,000 annually. With an annual project cost of $90,000 the benefit/cost ratio is 0.3 to 1 and the plan is not econmically justified. A system of dikes and walls to protect this same area to the same elevation will yield the same amount of benefits ($23,000). However, with an annual cost of $128,000 and resulting benefit/cost ratio of 0.2 to 1 this plan is also not economically justified.

The study also evaluated a proposal for the construction of a combination earth dike and floodwall at the Riverdale area. The alignments for the earth dike and floodwall can also be seen on Plate 6. The earth dike and floodwall were also designed to prevent damages for a 100-year flood event along this reach of the Mascoma River. Due to the minimum distance between the homes and the river in this area, it was necessary to design concrete walls to provide flood protection along 675 feet of the riverbank. Earth dikes could be utilized along the remaining 675 feet length necessary to tie into high ground. The dikes and walls in this area would have a maximim height of about 7 feet. The cost of a combination earth dike and floodwall in the Riverdale area was estimated to be $775,000 with an annual cost of about $70,000.

Benefits were calculated to elevation 586.5 and total $36,000 on an annual basis. The annual cost for this plan is $70,000 and the benefit/cost ratio is 0.5 to 1. The plan is not economically feasible.

Because of the excessive length and limited damages in these areas, it was determined that additional plans using other heights would not yield a justified plan and were not considered. The results indicate that both plans were not economically justified and therefore eliminated from further study.

The damage area along Route 4 in Canaan is located in a very extensive, low lying flood zone along a bend in the river. There is very little high ground in the area to tie the dike into. An earth dike would need to be over 2000 feet long and cannot be justified with the limited benefits in this area.

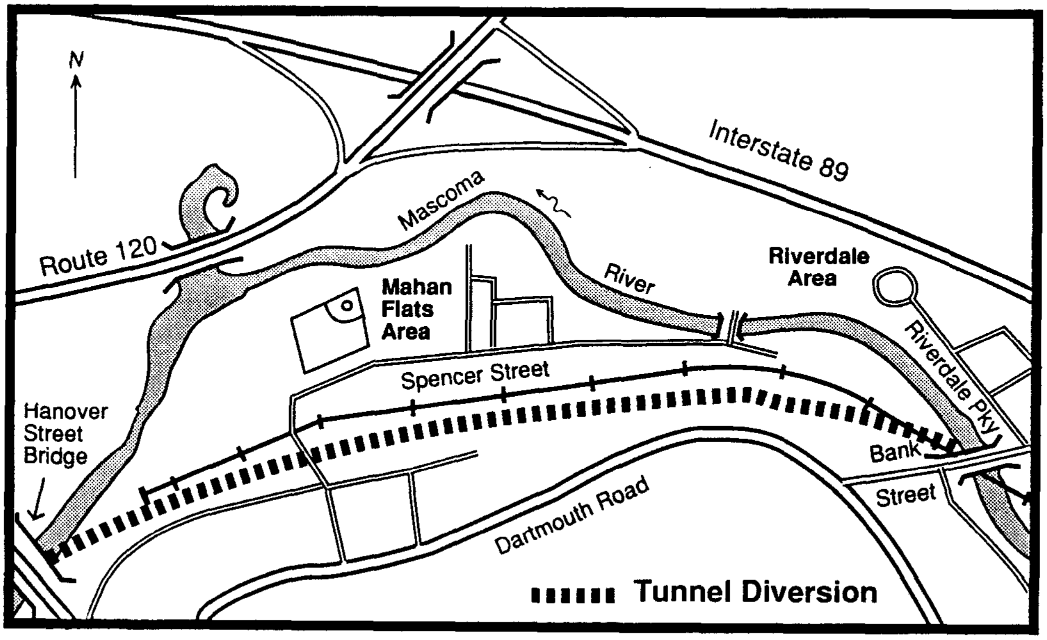
5.) **Channel Modifications.**

Within a given flood prone area, floodwaters escape the river channel when the discharge of a particular flood exceeds the carrying capacity of that channel. Accordingly, consideration was given to increasing the channel's flow capacity and removing obstructions to flow, thereby lowering the flood stage associated with a given discharge. Since all channels have a limit to their capacity, residual flooding occurs during events larger than that for which the channel is designed. Channel capacities can be improved by several methods, including widening and deepening the channel, increasing the slope of the channel, or improving the flow characteristics within a given channel.

TUNNEL DIVERSION ALTERNATIVE FOR THE 'MAHAN FLATS' AND RIVERDALE AREAS.

THE MASCOMA RIVER WOULD BE DIVERTED VIA AN UNDERGROUND TUNNEL FROM THE BANK STREET BRIDGE TO THE HANOVER STREET BRIDGE.

A TOTAL LENGTH OF THE DIVERSION TUNNEL IS APPROXIMATELY 3800 FEET.



MASCOMA RIVER BASIN

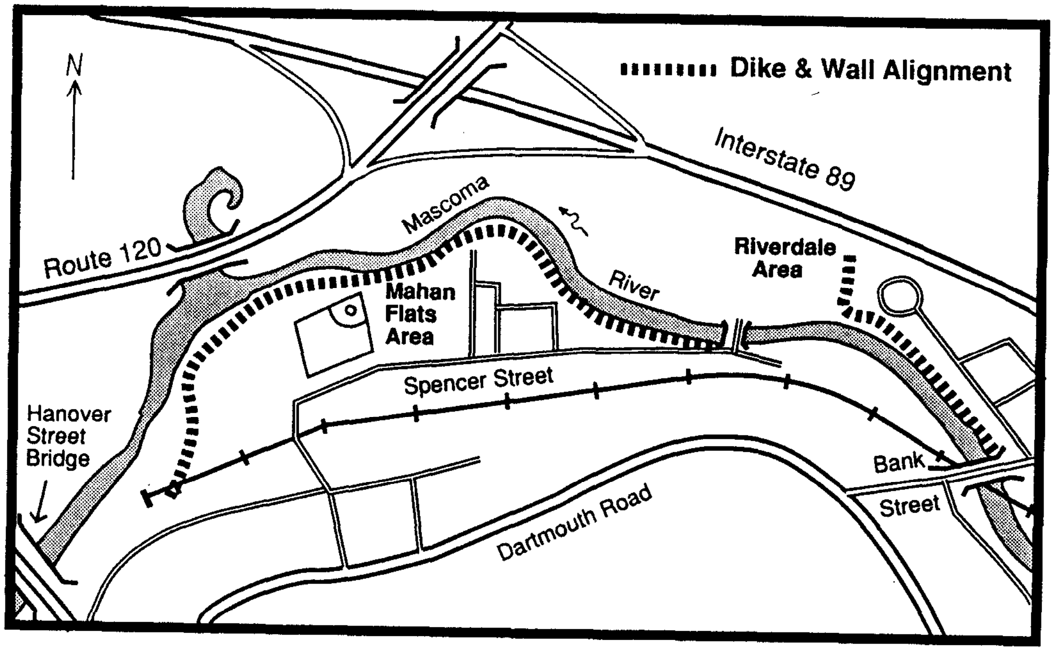
TUNNEL DIVERSION

PLATE 5

DIKES AND WALLS ALTERNATIVE FOR THE 'MAHAN FLATS' AND RIVERDALE AREAS.

THE MAHAN FLATS DIKE AND WALL ALIGNMENT WOULD BE FROM THE CONDEMNED BRIDGE TO A POINT JUST UPSTREAM OF THE HANOVER STREET BRIDGE, A TOTAL LENGTH OF APPROXIMATELY 2400 FEET.

THE RIVERDALE DIKE AND WALL ALIGNMENT WOULD BE FROM THE BANK STREET BRIDGE TO THE ROUTE 89 EMBANKMENT, A TOTAL LENGTH OF APPROXIMATELY 1350 FEET.



MASCOMA RIVER BASIN

DIKES AND WALLS

PLATE 6

The Mascoma River in Lebanon has a restricted channel capacity and flooding does occur, particularly in low lying floodplain areas. The present river channel is generally less than 100 feet in width and six to eight feet in depth. Estimated safe channel capacity through this area varies from 2,000 to 3,000 cfs as compared to the estimated 100-year discharge in the order of 7,000 cfs. While the existing channel approximates 600 to 1,000 square feet in cross sectional flow area, improvements necessary to provide an estimated 100-year level of protection would require doubling the flow area, whether accomplished through channel widening or by diking adjacent to the problem areas. Channel improvements would require about 6800 feet of widening, straightening and possible bridge reconstruction (see Plate 7).

Recently the city of Lebanon contracted Rivers Engineering Corporation of Manchester, New Hampshire to evaluate alternative channel improvement schemes in Lebanon (Mahan Flats). Rivers Engineering obtained extensive river cross section surveys and utilized the HEC-2 computer program to compute flood profiles. A base flood discharge of 7000 cfs (100 year) was used to screen alternatives. Various alternatives were analyzed and results were presented in a report titled "Channel Improvement Study, Mascoma River, Lebanon, New Hampshire, City of Lebanon Department of Public Works," dated August 1988. This report was used by the city as a screening tool for suggested improvements to flood control and not as construction work to be accomplished. The recommended alternative consists of channel modifications which include widening and deepening about 2500 feet of channel.

The recommended alternative, as recommended by Rivers Engineering, would reduce the 100-year flood event levels approximately 4.5 feet. The construction cost for the proposed alternative was estimated to be $2,860,000 with an annual cost of about $260,000.

The benefits to these modifications are a $17,300 reduction in annual losses versus the existing condition of the channel. However, the annual cost of the improvements is $260,000 which results in a benefit/cost ratio of 0.07 to 1 and a lack of economic justification.

6.) **Floodproofing.**

Floodproofing, by definition, is one of several techniques for preventing damages due to floods requiring adjustments both to structures and to building contents. It involves keeping water out as well as reducing the effects of water entry. Four primary techniques include floodproofing, raising, small walls or dikes and rearranging property within a structure.

<u>Floodproofing</u> - Structures whose exterior is generally impermeable to water can be made to keep floodwater out by installing watertight closures to openings such as doorways and windows. While some seepage will probably always occur, it can be reduced by applying a sealant to the walls and floors and by providing a floor drain where practical. Closures may be temporary or permanent. Temporary closures are installed only during a flood threat and, therefore, need warning time for installation.

As most residential structures in this area are of wood frame construction only the basement would be considered applicable for flood-proofing. Many of the industrial and commercial establishments in Mahan Flats are constructed of sheet metal and a few of concrete block. There are, however, several disadvantages to this means of protection. As mentioned above this method is applicable only to structures with brick or masonry type walls, and only to a level where they can withstand the hydrostatic and uplift pressure of the floodwaters. Another disadvantage is the reduced likelihood of effective closure at nights and during vacations when temporary closures are required; and lastly the entire measure may create a false sense of security and induce people to stay in the structure longer than they should. Most of the concrete block structures in the floodplain are old and not designed to withstand the hydrostatic forces that develop when a building is sealed to act as a flood retarding structure. Since this was the most common situation in Mahan Flats, Riverdale and along Route 4 in Canaan, floodproofing was not considered further as a viable solution.

Raising - Existing structures in flood hazard areas can often be raised in-place to a higher elevation to reduce the susceptibility of the structure to flood damage. Specific actions required to raise a structure include:

a. Disconnect all plumbing, wiring and utilities which cannot be raised with the structure.

b. Place steel beams and hydraulic jacks beneath the structure and raise to the desired elevation.

c. Extend existing foundation walls and piers or construct new foundation.

d. Lower the structure onto the extended or new foundation.

e. Adjust walls, steps, ramps, plumbing and utilities and regrade site as desired.

f. Reconnnect all plumbing, wiring and utilities.

g. Insulate exposed floors to reduce heat loss and protect plumbing, wiring, utilities and insulation from possible water damage.

These actions are intended to place the structure at a higher elevation at its existing site and to protect plumbing and utlilities previously below the first floor from water damage. Because the hazard is not eliminated, but only the damage potential reduced, it is important that the potential for flooding below the first floor be recognized in the raising. Lateral stability of the structure should be insured by redesigning the foundation walls. Such design would include the use of thick concrete mats for the floor slab and a structurally designed concrete wall. Both necessitate the use of reinforcing steel.

Some of the advantages to raising a structure are as follows. Damage to structure and contents is reduced for floods below the raised first floor elevation. It is particularly applicable to single and two story structures already on a raised foundation. There are no elevation limitations to raising a structure as long as the floodwaters are allowed to pass through the basement. Finally, the flood insurance premiums for the secondary layer of coverage are reduced.

Some of the disadvantages are as follows: Residential damages exist when floods exceed the raised first floor elevation. Minor damage may occur below first floor depending upon use. This measure is not generally feasible for structures with slab on grade foundations or for complete floodproofing measures where cellar flooding is not tolerated. Extensive landscaping and terracing may be necessary if the height raised is extensive.

For the purposes of this study it is estimated that the cost to raise a house in the study area would average $25,000. This estimate is based on information obtained for other ongoing flood control studies of similar structures in the New England area. Therefore, the cost to raise the 26 homes in Mahan Flats would cost about $650,000 with an annual cost of about $58,000.

Benefits for this improvement measure are the difference in annual losses for each structure with the first floor at its existing elevation versus the elevation after raising the first floor to one foot higher than the 100 year flood level. Total annual benefits which accrue to raising the first floors of the 26 residential structures in this area amount to $10,300. With an annual cost of $58,000 and a benefit/cost ratio of 0.2 to 1, the plan is not economically justified.

The cost to raise the 58 homes in Riverdale would be about $1,400,000. Benefits were estimated for raising the first floor of 58 residences and totalled $22,700. The plan for this area was also not justified with an annual cost of $126,000 and a benefit/cost ratio of 0.2 to 1.

<u>Small Walls or Dikes</u> - This measure consists of a minimal height wall or dike, generally less than 6 feet, designed to protect one or several structures and built to be compatible with local landscape and aesthetics. Walls may be of any suitable material and so designed as to resist the lateral and uplift pressures associated with flooding. Dikes are usually constructed with an impervious core to prevent seepage and with a slope protection if erosion is a problem. Where access openings are necessary, provisions must be made to close their opening during floods. Interior drainage facilities such as a small sump pump may be necessary to control the land and roof runoff.

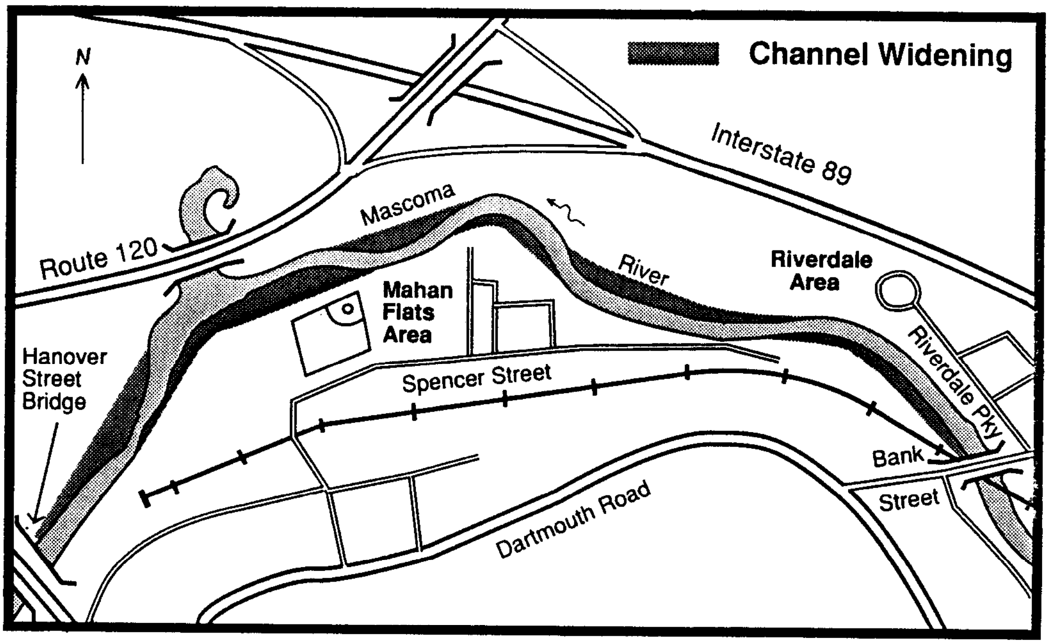
Benefits are estimated for small walls and dikes in the identical manner used for large walls and dikes. To identify candidate properties for small wall and dike plans recurring losses were examined. The only property which exhibited significant damage potential was the Emerson Greenhouse located in the Mahan Flats area. Recurring losses for this property are $6,500 for a 10-year event, $55,400 for a 50-year event and $66,500 for a 100-year event. Expected annual losses are $3,400. The 900 foot long small dike for this property would produce annual benefits of $3,000, but with an annual cost of $18,000 and a benefit/cost ratio 0.2 to 1, the plan is not economically justified.

<u>Rearranging or Protecting Damageable Property Within an Existing Structure</u> - Within an existing structure or group of structures damageable property can often be placed in a less damageable location or protected in-place. It is something every property owner can do to one degree or another depending upon the type and location of the susceptible property and upon the severity of the flood hazard. Some of the possibilities are as follows:

CHANNEL WIDENING ALTERNATIVE FOR THE 'MAHAN FLATS' AND RIVERDALE AREAS.

THE MASCOMA RIVER WOULD BE WIDENED FROM THE BANK STREET BRIDGE TO THE HANOVER STREET BRIDGE.

A TOTAL LENGTH OF THE CHANNEL WIDENING IS APPROXIMATELY 6800 FEET.



MASCOMA RIVER BASIN

CHANNEL WIDENING

PLATE 7

a. Protecting furnaces, water heaters, air conditioners, washers, dryers, shop equipment and other similar property by raising them off the floor. This may be appropriate for shallow flooding conditions.

b. Relocating damageable property to higher floors. Moving property from the basement to the first floor or second floor would be an example. This action usually requires ducts, plumbing and electrical wiring and making space available at the new location.

c. Relocating commercial and industrial finished products, merchandise and equipment to a higher floor, or adjacent and higher building, or to a less flood-prone site.

d. Anchoring all property which might be damaged by movement from floodwater.

Rearranging or protecting property within and around a particular business can help reduce damage during a flood. Implementation of this type of measure, however is a local business' responsibility and not considered for further Federal investigation.

6.) **Relocation.**

Permanent relocation is the complete evacuation of existing activities to locations not susceptible to flood damage. Relocation may consist of: the physical movement of structures to new locations, the demolition of structures at floodprone locations and the construction of new buildings at different locations, or the demolition of structures and provision of funds for purchase of new buildings. Benefits for permanent location are classified into five categories: (1) the value of the new use of the vacated land, (2) reduction in damage to public property, such as roads and utilities, (3) reduction in emergency costs, (4) reduction in the administrative costs of disaster relief and (5) reduction in the flood insurance subsidy. No benefit is taken for the reduction in private flood damage because it is assumed that expected flood losses are, for the most part, reflected in lower property values of floodplain properties. In the benefit/costs statement, because the reduced property values lower the costs of relocation, it would be double counting to also include reduced physical damages in the benefits. Of the 5 benefit categories stated above, the first, the value of the new use of the vacated land is critical to the economic justification of a relocation plan. The land must have considerable value in its new use. The land in Mahan Flats, Riverdale and Canaan was not projected to have high value after implementation of a relocation plan. Its most probable use would be park or recreation land. Because of its limited size, geographical location and floodprone nature, it would not become highly valued, income-producing land such as agricultural land. In reference to the other four benefit categories, benefits were also expected to be minimal based on the existing level of annual losses in relation to the number of properties. Economic justification for relocation is extremely doubtful when considering the cost to relocate 101 structures versus the benefits for lower land values, minimal public savings (benefit categories 2, 3 and 4) and minimal reduction in the flood insurance subsidy (category 5) due to property losses averaging less than $700 annually.

The previous description discussed relocating and protecting damageable property within an existing structure. However, at certain times, this is no longer feasible. This section discusses two options for removing property to a location outside the flood hazard area.

One option is to remove both structure and contents to a flood free site. This involves:

a. Locating and purchasing land at a new site.

b. Preparing the new site, services, driveway, sidewalk and new foundation.

c. Raising structure off its existing foundation, transporting it to the new site and placing it on this new foundation.

d. Moving contents from existing to new location.

e. Removing, disposing and backfilling the foundation at the existing site.

f. Providing temporary lodging during relocation.

A second option is to remove only the contents to a structure located at a flood free site and demolish the existing site. This measure includes:

a. Locating an existing structure, or building a new structure at a flood free site.

b. Moving contents from an existing to a new location.

c. Either demolishing, and where possible salvaging the existing structure, or reusing it for a less damage susceptible use.

7.) **Land Use Regulations and Zoning.**

An important management tool in the control of future flood losses is land use planning directed to limit the types of activities located in the flood plain. Lebanon, Canaan and Enfield are enrolled in the regular program of flood insurance and the communities have accepted the terms for future land use dictated by that program. To insure the success of the flood insurance program, the community should adopt a plan for future land use, directing intensive damage-prone development away from the flood plain. In addition, development outside the flood plain should also be carefully planned so as not to increase runoff rates into the river. Implementation of sound land use measures is a community responsiblity and is, therefore, not considered for further investigation.

8.) **Flood Warning and Emergency Evacuation.**

As a further effort to provide some protection against flood losses, automated or nonautomated warning systems can be used to alert citizens of impending flooding so they can evacuate the flood plain for personal safety and secure valuable property against flood damage. Warning systems rely on precipitation and stream gages positioned in the upper basin to monitor rainfall and riverflows, and based on developed floodflow models, predict flood stages in downstream areas. Warning systems are most valuable for their ability to save lives. Beyond that they can serve to reduce economic losses if residents take precautions to elevate property above the expected flood stage or sandbag access points to their structures. For flood warning systems to be effective, an adequate warning time is required to allow residents and businessmen to react and remove damageable property. Mascoma Lake is a major hydrologic index and is located about 4 miles above Lebanon, the major damage center. Average channel slope from Mascoma Lake dam to Lebanon is over 40 feet per mile, therefore, the resultant travel time is extremely short. As mentioned previously total storage capacity within Mascoma Lake is relatively small, less than one inch of runoff from the upstream watershed. Also, the lake is used heavily for recreation and is maintained at spillway crest from May to September. In addition, the spillway crest length is relatively large resulting in large increases in discharge for relatively small increases in stage. A flood warning system could be developed, however, would require monitoring lake inflows, change in storage and resulting outflows. Such a system would be dependent on many factors with resulting variable warning times. It would be difficult to provide an effective, reliable warning system that would provide significant warning time within this watershed.

9.) **Regulation of the Existing Reservoirs.**

The possibility of increasing the flood control effectiveness of existing reservoirs within the watershed was investigated. Essentially 100 percent of the storage in the watershed is located in Mascoma Lake and impoundments upstream of the lake. A review of the watershed map reveals that the majority of the impoundments upstream of Mascoma Lake are located in the headwaters of small tributaries with relatively small drainage areas. For the most part these are small recreational ponds with little impact on peak discharges. Modification of their operation in the interest of flood control is viewed as impractical. Mascoma Lake however, with a surface area of 1200 acres, recreational storage capacity of 8300 acre-feet and a drainage area of 153 square miles can have a modifying effect on peak flows. This is demonstrated by a review of the recorded peak discharges along the Mascoma River at West Canaan (80.5 sq. mi.) and at Mascoma Lake (153 sq. mi.). The gage at West Canaan is located upstream of Mascoma Lake and its watershed has several small impoundments located in the headwaters. The period of record at this gage is from 1938-1978 with the largest recorded flood flow of 4310 cfs (55 cfs/square mile) in September 1938. This same flood event recorded at the gage directly downstream of Mascoma Lake had a peak discharge of only 4400 cfs (29 cfs/square mile). Two other significant flood events where data is available at West Canaan and Mascoma are in March 1953 and July 1973. Peak discharges at West Canaan were 3780 cfs (47csm) and 3150 cfs (39 csm) respectively. Recorded discharges downstream of Mascoma Lake were 4880 cfs (32 csm) and 4260 cfs (28 csm) respectively for the same two flood events. As can be seen peak flow rates downstream of the lake are 30-50 percent less than those recorded upstream. Therefore, Mascoma Lake is currently reducing peak discharges either by having storage available prior to the flood event, through the use of surcharge storage or by desyncronizing peak flows. Requirements necessary to further reduce peak flows by utilizing Mascoma Lake were explored.

Mascoma Lake has a total of approximately 1.0 inch of runoff. Present operating procedures, by the New Hampshire Water Resources Division, are to draw the lake down 4.0 feet in the winter and early spring and refill again in late spring. Therefore, this procedure currently has an effect on peak discharges in the watershed. The total storage capacity in Mascoma Lake is relatively small (1 inch of runoff). Assuming 100 percent of this storage capacity is available for flood control, it is estimated that significant reduction would occur for the more frequent flood events. However, during a major flood event the lake most likely would fill very quickly and significant reduction to peak flows probably would not occur.

If the reservoir was drawn down about four feet and maintained at that level, during all seasons, only about 0.5 inch of runoff for flood control storage could be obtained. This procedure would have little effect on flooding and is viewed as impractical due to heavy recreational use. Because of the relatively small storage capacity of Mascoma Lake, use of this impoundment for flood control would be quite limited. The existing practice by the State of drawing down the reservoir 4 feet during the winter and filling during the spring is the most practical operation of the Mascoma Lake Dam.

10.) **Flood Insurance.**

For those properties that cannot be completely protected against flood damages, the National Flood Insurance Program is available to assist and compensate flood plain residents for their losses. Flood insurance does not cover all the losses that may occur in a flood, it does cover property damage and loss of personal possessions to a much greater degree than disaster relief. Reimbursement is the primary function of the flood insurance program. However, as a precaution against future increases in flood insurance claims, communities enrolled in the regular program of flood insurance are required to implement land use controls which regulate different types of flood plain development.

For example, once a community has been accepted into the regular phase of the Flood Insurance Program, new residential properties constructed in the flood plain must have first floor elevations above the 100-year flood stage, and new commercial and industrial buildings must be floodproofed to the level of the 100-year flood. Of course, no development is allowed to occur within the floodway. Property owners in the flood plain should be encouraged to purchase flood insurance coverage for their property as a precaution against future flood damages.

New home mortgages and business loans now require that flood insurance protection be obtained for a flood prone property; eventually it is likely that the majority of flood plain properties will have insurance coverage. Implementation of this program is also a community responsibility. Inasmuch as flood insurance is presently available to Lebanon flood-prone properties, this measure is considered part of the "without project conditions" and was not considered an alternative. Further, in the absence of a flood protection plan that reduces actual damages, purchasing of flood insurance is recommended.

2. Summary of Screening

As a result of the initial screening of flood damage reduction alternatives for the Mascoma River Basin, it was determined that none of the alternatives warrant further Federal involvement. Neither the basin wide options such as constructing or modifying upstream reservoirs or flood warning and evacuation, nor the site specific options such as channel modification or walls and dikes could be justified. The alternatives considered are shown in Table 9.

TABLE 9

FLOOD DAMAGE REDUCTION ALTERNATIVES
MASCOMA RIVER BASIN

Alternatives	Total Cost ($000's)	Annual Cost ($000's)	Annual Benefit ($000's)	B/C Ratio
Mahan Flats and Riverdale				
Channel Widening	2,860	260	17	0.07
Earth Dikes	1,775	160	59	0.4
Dikes and Walls	2,175	196	59	0.3
Diversion	10,500	945	54	0.06
Mahan Flats only				
Earth Dikes	1,025	90	23	0.3
Dikes & Walls	1,425	128	23	0.2
House Raising	650	58	10	0.2
Riverdale only				
Walls and Dikes	750	70	36	0.5
House Raising	1,400	126	23	0.2

It is evident that no structural or nonstructural solutions warrant Federal expenditures. However, in order to preclude a situation where conditions result in increased flooding, it is recommended that all communities in the watershed, particularly those in which wetlands remain in relatively undisturbed conditions, enact strict floodplain zoning. If uncontrolled urbanization is allowed in the floodplain, future increased flooding can be expected to occur.

E. Conclusions

The study has concluded that there is no Federal interest in implementing flood damage reduction measures in the Mascoma River Basin. An investigation of all potential alternatives to alleviate the flood problem has been completed by this study effort. There are many measures available to lessen and/or eliminate the impact of flooding in the area. However, none of the measures discussed in this report meet the criteria for Federal involvement.

There are some measures local officials, residents and businessmen in the area can take to decrease the impact of flooding. Everyone in the flood prone areas of Mahan Flats, Riverdale and Canaan should have or be encouraged to purchase flood insurance. Businessmen and home owners may be able to elevate or remove damageable property out of the flood zone to a higher elevation. These measures will not eliminate the flooding but will certainly lessen the financial impact when a flood does occur.

The State of New Hampshire Water Resources Division has been very effective in decreasing the impact of flooding in the Lebanon area by regulating Mascoma Lake. They are encouraged to continue this practice in the future.

F. Recommendations

It is recommended that no further study be conducted under this authority.

Date

Colonel, Daniel M. Wilson
Division Engineer

G. Acknowledgements

This report was completed by the New England Division Army Corps of Engineers under the general direction of Colonel Daniel M. Wilson, Division Engineer. It was prepared by Mr. Robert Martin, Project Manager, under the supervision of Mr. F. William Swaine, Chief Project Development Section and Mr. Joseph L. Ignazio, Chief Planning Division.

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ENVIRONMENTAL CONSIDERATIONS

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A. ENVIRONMENTAL SETTING

1. General

The Mascoma River, a tributary of the Connecticut River, is located in west-central New Hampshire and drains a basin of approximately 194 square miles. The headwaters of the watershed are formed by a series of small lakes and ponds located in the towns of Grafton, Canaan, and Enfield, New Hampshire. These ponds and lakes drain by small streams into the 1,150 acre Mascoma Lake. From the outlet of the lake, Mascoma River flows 10.2 miles through the city of Lebanon to its confluence with the Connecticut River. The water bodies in the Mascoma River watershed are operated for storage for power, flood control and recreation by the New Hampshire Water Resources Board.

2. Topography and Geology

The watershed consists of upland hills and peaks in the northern and eastern portions, then more gently rolling hills in the western portion near the Connecticut River. Elevations in the watershed range from 3200 feet msl in the headwaters to 340 feet msl at the confluence with the Connecticut River. In the project area, elevations range from 800 feet msl at West Canaan to 580 feet msl at Mahan Flats in Lebanon.

The project area is underlain by bedrocks which are generally Paleozoic in age. These rocks consist of "Ordovician, Silurian, and Devonian sediments and Devonian and Carboniferous igneous rocks." (New England New York Inter-agency Committee, 1955). The original sedimentary rocks have been altered to schist, quartzite, slate, gneiss, and other metamorphic rocks.

The surficial geology of the area is primarily glacial till consisting of a mixture of clay, silt, sand, gravel, cobbles and boulders. Overlying the till are stratified materials laid down in glacial lakes and glacial streams. These deposits are composed of bedded sands and gravels or clay and silt.

3. Water Quality

From the outlet of Mascoma Lake to its confluence with the Connecticut River, the Mascoma River has been subjected to pollution from many sources in the areas of Lebanon and West Lebanon (State of New Hampshire, 1982). These sources primarily include domestic and municipal sewage outfalls. The City of Lebanon's wastewater treatment plant is located at the mouth of the Mascoma River.

The legislative classification by the New Hampshire Water Supply and Pollution Control Commission (1988) for the Mascoma River in the project area is as follows:

Class A - from the Mascoma Lake outlet to the Lebanon Waterworks Intake
Class C - from the Waterworks downstream to the mouth

Class A waters are of the highest quality, with no discharge of any sewage or wastes. They are potentially acceptable for water supply uses after disinfection. (NHWSPC, 1988)

Class C waters are of the third highest quality and are potentially acceptable for recreational boating, fishing, and industrial water supply following adequate treatment. Dissolved oxygen use standards require that the use not result in less than 5 mg/l dissolved oxygen in warm water fisheries and not less than 6 mg/l dissolved oxygen in cold water fisheries unless naturally occurring. (NHWSPC, 1988).

Data collected during a sampling program in 1982 (Attachment 1) indicated that there could still be sources of untreated sewage entering the Mascoma River which lower the existing water quality below the legislated water use classification. The data showed that bacterial contamination increases rapidly within the more congested areas, and the river is unable to recover from this contamination before its confluence with the Connecticut River (NHWPC, 1982). A new sewerage and wastewater treatment plant is planned for construction that is expected to correct the discharges, except for some combined sewer overflows.

Results of sampling conducted by the New Hampshire Water Supply and Pollution Control Commission in June 1988 was not available for inclusion in this report.

4. Natural Resources

A wide variety of fish and wildlife resources can be found in the Mascoma River watershed. Most of the watershed is covered by a forest zone characterized by northern hardwoods, such as sugar maple, red maple, yellow birch, beech, red oak and ash. (Cowardin, 1979). Hemlock and white pine are also closely associated with the hardwood species. In the upper reaches of the basin, forest species consist mainly of red, white and black spruces and balsam fir. Timber harvesting, forest fires and varying soil conditions have altered some of the forest patterns in the region.

The edge effect created by riparian vegetation, open grassy areas, forest and open and flowing water provides excellent habitat for many species of birds and mammals. Birds that frequent the basin and the project area include: red-tailed hawk, broad-winged hawk, downy woodpecker, pileated woodpecker, great horned owl, crows, belted kingfisher, red-winged blackbird, green-backed heron, great blue heron, spotted sandpiper, black-capped chickadee, mallard ducks, wood ducks, mergansers, ruffed grouse and woodcock.

Wildlife species common to the basin include: raccoon, skunk, beaver, porcupine, muskrat, mink, red fox, New England cottontail, whitetail deer, shrews, voles, mice, red and gray squirrels, and long and short-tailed weasel.

Pool-riffle habitat with gravel/cobble substrate and low gradient areas with sandy substrate provide for excellent fisheries habitat in the basin and project area. Brook, brown, and rainbow trout are stocked annually by the New Hampshire Fish and Game Department. In 1987, a total of 9248 trout (6940 brook, 1608 brown and 700 rainbow) were stocked in the Lebanon-Enfield area. (USFWS, 1988). Other species that occur in the Mascoma River, influenced by the presence of Mascoma Lake, include: smallmouth bass, rock bass, yellow perch, brown bullhead, common sucker, eastern and common shiners, creek chub, fall fish, eastern black and long-nosed dace, eastern johnny darter, and slimy sculpin. The river offers easy fishing access in many places throughout the basin.

The Connecticut River Atlantic Salmon Restoration Program will in time affect fishery management in the Mascoma River. This program is a Federal and State cooperative effort to restore and maintain Atlantic salmon in the Connecticut River basin to provide for both natural spawning populations and a sport fishery. The Mascoma River has not been designated as one of the initial ten high priority rivers for restoration. It is presently in a deferred status. Once the long-term program goal of full watershed utilization is realized, fish passage will likely be required at the dams along the Mascoma River to allow the reintroduction of anadromous species into the basin. (USFWS, 1988).

Wetlands in the Mascoma River basin are of the palustrine type, which include emergent, scrub/shrub and forested wetlands. (Cowardin, 1979). Vegetation in these wetlands consists of cattails, bulrushes, sedges, red maple, willows, and various species of oaks and evergreens.

5. Threatened, Rare and Endangered Species

According to the U.S. Fish and Wildlife Service by letter dated August 22, 1988, there are no Federally listed or proposed endangered or threatened species in the Mascoma River basin. The New Hampshire Natural Heritage Inventory provided a list by letter dated 22 November 1988 of rare plants, animals and natural communities known from within the boundaries of the study area. This list is found in Attachment 2. A field survey for any of these species would be required should work be proposed in the study area.

6. Cultural Resources

See Appendix C.

7. References

U.S. Department of the Interior (USDI). 1988. Endangered Species Letter, prepared by the U.S. Fish and Wildlife Service dated August 22, 1988.

U.S. Department of the Interior (USDI). 1988. Planning Aid Letter prepared by the U.S. Fish and Wildlife Service dated August 31, 1988.

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Cowardin, L.M., V. Carter, F.C. Golet and E.T. LaBoe, 1979. Classification of Wetlands and Deepwater Habitats of the United States, U.S. Fish and Wildlife Service, FWS/OBS - 79/31.

Application for License for Minor Project, Glen Hydro Project, Mascoma River, Lebanon, New Hampshire, Project No. 8405-002, April 1985.

New Hampshire Water Supply and Pollution Control Division, Legislative Classification of Surface Waters, 1988, and Mascoma River Survey, 1982.

The Resources of the New England-New York Region, Volume 1, Part 2, Chapter 21, Connecticut River Basin, New England New York Inter-agency Committee, 1955.

B. ENVIRONMENTAL CONSIDERATIONS

Various flood control measures were studied to reduce flooding in the lower reaches of the Mascoma Rvier Basin, specifically in three areas: the Mahan Flats and Riverdale areas in Lebanon, and the Route 4 area in Canaan. These alternative measures included the regulation of existing reservoirs, construction of dikes (levees) and floodwalls, channel modifications, and nonstructural measures. Environmental considerations of these alternative measures and specific considerations at the damage areas in Lebanon and Canaan are discussed below.

1. Reservoir regulation

Reservoir regulation was considered as an alternative to reduce flooding prior to reaching the damage areas in the lower basin. Although there are a number of lakes and reservoirs in the basin that could be regulated, only Masoma Lake was identified as a possible consideration.

Mascoma Lake is presently used for water storage, downstream flow regulation, and recreation. The lake is regulated by having a full pool to elevation 751 for recreation during the summer, then drawing it down four feet starting in October for winter storage. Regulation for additional flood storage would require a drawdown of an additional six to twelve inches.

There would be a number of impacts associated with an additional drawdown of the lake. Fish, wildlife, and vegetation in the exposed littoral zone would be primarily affected (USFWS, 1988). Food and cover could be reduced for aquatic organisms by the loss of algae and vascular plants. Downstream resources could be affected depending on the rate of releases.

A number of studies as outlined by U.S. Fish and Wildlife Service would have to be accomplished to further define impacts associated with a re-regulation of Mascoma Lake. These would include a determination of: the flow release rate to determine impacts on downstream fisheries, the amount of exposed shoreline, and the distribution of wildlife and vegetation along the exposed shoreline (USFWS, 1988).

2. Dikes and Floodwalls

Mahan Flats

The Mahan Flats area, located to the south of the Mascoma River, was identified as a flood damage area. It is characterized by four covertypes: deciduous riparian vegetation, grasslands, emergent wetlands, and urbanized areas (USFWS, 1988). Dense riparian vegetation is found along both sides of the river. This area consists of a variety of tree, shrub, and herbaceous species which provide excellent habitat for bird and wildlfe populations.

Emergent wetlands can be found primarily in the backwater areas. Vegetation consists primarily of cattails and tussock sedge, and these areas also provide excellent wildlife habitat.

The grassland area separating the riparian covertype from the urban covertype consists of several species of upland grasses and pioneering species such as sumac, aspen and poplar (USFWS, 1988).

This area has most likely been previously disturbed. The remainder of the Mahan Flats area is made up of a playfield, a recreation center, residential homes, roads and commercial businesses.

Construction of dikes (levees) and walls were considered for this area. The alignment would be from the condemned bridge at the end of Spencer Street downstream to a point just upstream of the Hanover Street Bridge, a distance of approximately 2400 feet.

Impacts associated with a dike and wall alignment would include the direct loss of habitat from the placement of the structures and disturbance from construction activities. The high quality riparian habitat would be eliminated at the project site, which includes the overhanging bank cover, and possibly some of the shallow water fisheries habitat. The backwater wetland areas could be affected should seasonal high flows be prevented from recharging these areas (USFWS, 1988). Construction activities would degrade water quality conditions through increased sedimentation. Wildlife in adjacent areas would be temporarily displaced, and, depending on the time of year of construction, could disturb nesting areas.

Fishing access would be disrupted or eliminated, as well as the scenic views of the river by the presence of a structure along the riverbank. A dike alignment could provide potential for planting of trees and shrubs and better access as opposed to floodwalls.

Impacts could be lessened by the placement of structures back of the river bank and riparian habitat. Also, less area would be disturbed with the use of more floodwalls instead of dikes.

Riverdale

The Riverdale portion of the project extends from the railroad tracks upstream of the Bank Street Bridge crossing downstream to the I-89 embankment. The damage area consists of residential structures along Riverdale Parkway and the grassy/vegetated areas behind these residences. This area has three covertypes: deciduous riparian vegetation, wooded grasslands, and residential areas (USFWS, 1988).

The deciduous riparian vegetation is found throughout the site between the river and residences. This area has been disturbed, but provides good shade and overhanging bank cover for many wildlife species. The open ground cover, interspersed with the red maples, willows, elms and elders, consists of vine species and escaped ornamentals (USFWS, 1988). The wooded grassland area is former pasture land made up of pioneering trees and shrubs (sumac, poplar and aspen), honeysuckle, raspberry, and grassy patches. This variety of habitat supports wildlife species such as cottontail, pheasant, fox, and whitetail deer.

Construction of dikes and floodwalls in the Riverdale area would result in similar impacts as discussed for Mahan Flats. Because of the closeness of the residences to the river in this area, and the narrow band of riparian habitat, dikes or walls would greatly encroach on the streambank. Impacts on wetland areas would be less than at Mahan Flats. There would be direct loss of habitat from construction of the structures, and disturbance to wildlife species during construction.

Route 4

This damage area is located to the north of Route 4 and to the west of the Mascoma River. The area is primarily pasture with grasses, open ground, poplar and birch trees. Small areas of palustrine wetlands (approx. 0.25 acres in size), most likely recharged by the flooding of the Mascoma River, are found along the river (USFWS, 1988). Immediately along the river there is typical riparian habitat consisting of large red maple trees that provide good cover and shade, as well as dogwood, birch, elm, white pine and red oak.

Again, impacts associated with the construction of dikes and floodwalls would be similar to those discussed for the other damage areas. Structures should be constructed as far back from the river as possible to avoid impacting the riparian habitat, and to insure that the structures would not encroach on any wetland areas.

3. Channel Modification

Channel widening and deepening would result in adverse impacts to fish and wildlife habitat at all alternative project sites. Aquatic organisms present in the substrate would be destroyed, as well as the associated habitat, such as pools and riffles, streambank cover, and shading. Wetland areas adjacent to the river could be directly affected by loss of vegetation, and indirectly through the loss of flooding in the backwater areas and sediment deposition (USFWS, 1988).

Downstream conditions could also be affected by this alternative during construction by increased turbidity. Increased velocities in downstream reaches could increase erosion and sedimentation, impacting fish and wildlife resources.

4. Nonstructural Alternative

Nonstructural measures include floodproofing structures or raising structures to prevent flood damage. This alternative would not impact fish and wildlife resources, and has the least environmental impact of any of the alternatives. Only minor and temporary construction associated effects such as increased noise and dust conditions would occur.

C. COORDINATION WITH FEDERAL AND STATE AGENCIES

1. U.S. Fish and Wildlife Service

The U.S. Fish and Wildlife Service (USFWS), Ecological Services, Concord Field Office, participated in a field visit with Corps staff to the study area on July 7,1988. A Planning Aid letter dated August 31,1988 has been provided. USFWS stated that all of the structural alternatives have the potential to cause adverse impacts to fish and wildlife resources in the Mascoma River. They recommended methods to minimize impacts from the construction of dikes and floodwalls. Nonstructural measures were recommended as a solution essentially free of impacts to fish and wildlife resources.

A letter dated August 22,1988 from USFWS concerning Federally listed and proposed endangered or threatened species stated that there were no listed species for the Mascoma River basin.

2. U.S. Environmental Protection Agency

A letter from EPA dated October 24,1988 stated that the structural alternatives would cause major impacts to the aquatic environment by altering the riparian habitat. EPA prefers the non-structural alternatives because of their minimal impact on the aquatic environment.

3. New Hampshire Fish and Game Department

A letter was received from New Hampshire Fish and Game dated Septmber 23,1988. It stated that nonstructural measures were preferred as they do not have the potential to adversely impact fish and wildlife resources.

D. CORRESPONDENCE

See Appendix D.

APPENDIX A

HYDROLOGIC REPORT

MASCOMA RIVER WATERSHED
NEW HAMPSHIRE
HYDROLOGIC RECONNAISSANCE REPORT

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HYDROLIC RECONNAISSANCE
MASCOMA RIVER
NEW HAMPSHIRE

1. PURPOSE AND SCOPE

This report presents hydrologic information and analysis including an update of the hydrology developed for the 1972 Flood Plain Information Report of the Mascoma River. Included are sections on basin description, climatology, flood history, flood frequencies, flood problem areas, and stage frequencies. Also included are sections on flood control alternatives, existing reservoirs and summary conclusions. The purpose of this evaluation is to provide hydrologic information to Planning Division for use in the Mascoma River Basin Reconnaissance Study. This study was performed under authority vested in the congressional resolution adopted by the Committee on Environment and Public Works of the United States Senate, dated 26 September 1984.

2. BASIN DESCRIPTION

a. General. The Mascoma River Basin lies wholly in New Hampshire and has a total watershed area of 194 square miles. The topography of the basin is marked by several small mountains with elevations ranging from about 3,200 feet above NGVD at the upper or northerly end of the basin to about 324 feet in the streambed at its mouth. The river has its source at Reservoir Pond in Dorchester, NH and from this point to Canaan Center the river is relatively steep with an average slope is about 39 feet per mile. From Canaan Center to Mascoma Lake the average slope is about 13 feet per mile while from Mascoma Lake to the mouth of the Mascoma River the average slope is about 42 feet per mile, with the greatest drop in this reach being in the city of Lebanon. There is however a very flat reach of river upstream of the former Cummings Dam in Lebanon. This area is known as "Mahan Flats" and has an average channel slope of only about 8 feet per mile. A watershed map of the Mascoma Basin is shown on Plate 1.

b. Mascoma River. The Mascoma River originates at the outlet of Reservoir Pond on the boundary between Dorchester and Lyme. It flows southerly through Dorchester into Canaan, then westerly through Canaan, Enfield and Lebanon to its confluence with the Connecticut River about 0.8 miles south of the community of West Lebanon. On its course the river flows through Mascoma Lake with a surface area of 1,200-acres located in Enfield. The river is about 35 miles long and has a total fall of about 1,017 feet. The watershed is characterized by numerous ponds and marshy flats. The most significant water body is Mascoma Lake located along the Marcoma River about midway in its course to the Connecticut River. The ponds and Mascoma Lake are controlled by dams which have the capability of regulating the streamflow slightly. Pertinent drainage areas of the Mascoma River are given in Table 1.

TABLE 1

DRAINAGE AREAS IN

MASCOMA RIVER BASIN

Location	River Mile	Drainage Area (sq. mile)
USGS Gaging Station* West Canaan, N.H.	18.2	80.5
USGS Gaging Station Mascoma, N.H.	10.0	153
Confluence with Connecticut River	0	194

* discontinued in 1978

3. CLIMATOLOGY

a. General. The Mascoma River Watershed lies within the southern New England region. This region is semihumid with an average annual precipitation of about 35 inches, and has a variable climate characterized by frequent but generally short periods of heavy precipitation. It lies in the path of the "prevailing westerlies" and is exposed to cyclonic disturbances that cross the country from the west or southwest. This region is also exposed to coastal storms that travel up the atlantic seaboard in the form of hurricanes of tropical origin. The temperature within the basin ranges from occasional highs in the 90's to subzero lows in the winter. Spring melt of winter snow throughout most of the basin occurs generally in late March and April.

b. Temperature. The mean annual temperature of the watershed is about 45° Fahrenheit. Extremes in temperature range from highs in excess of 90 degrees to subzero lows. Mean temperatures at Hanover, NH located adjacent to the Mascoma River watershed are shown in table 2.

TABLE 2

MONTHLY TEMPERATURES
HANOVER, NEW HAMPSHIRE
(98 Years of Record)

Month	Mean Temperature °F
January	17.9
February	19.7
March	29.9
April	42.9
May	55.1
June	64.1
July	69.0
August	66.6
September	59.1
October	47.7
November	35.5
December	22.4
Annual	44.7

c. Precipitation. The mean annual precipitation of the watershed is about 35 inches. The greatest annual precipitation recorded at Hanover was over 50 inches in 1983. Table 3 summarizes mean, maximum and minimum precipitation as recorded at Hanover, New Hampshire.

TABLE 3

MONTHLY PRECIPITATION
HANOVER, NEW HAMPSHIRE
(140 Years of record)

	Mean	Maximum	Minimum
January	2.67	6.76	0.31
February	2.36	7.67	0.27
March	2.63	8.25	0.20
April	2.73	6.26	0.07
May	3.17	7.37	0.55
June	3.35	7.42	0.43
July	3.51	9.69	0.51
August	3.42	10.19	0.12
September	3.22	8.88	0.27
October	3.05	9.29	0.12
November	2.88	8.67	0.55
December	2.74	7.69	0.61
Annual	35.73	55.85	22.69

d. Snowfall. Average annual snowfall for 58 years of record is 73.4 inches. Snowfall values are shown in table 4.

TABLE 4

MEAN MONTHLY SNOWFALL
HANOVER, NEW HAMPSHIRE
(94 years of record)

	Inches
January	18.1
February	18.0
March	12.5
April	4.3
October	0.2
November	5.5
December	14.6
Annual	73.4

4. STREAMFLOW

The U.S. Geological Survey maintains a stream gaging station on the Mascoma River in Mascoma, New Hampshire. The station is located 1,000 feet downstream of Mascoma Lake Dam, and has a drainage area of 153 square miles. The station has been maintained since August 1923 and has an average annual flow of 216 cfs which is equivalent to 19.2 inches of runoff or approximately 50 percent of average annual precipitation. Flow rates recorded at this location are effected by storage in and regulation of Mascoma Lake. Estimated mean, maximum, and minimum monthly flows for the Mascoma River are shown in Table 5.

TABLE 5

MASCOMA RIVER RUNOFF
(DA - 153.0 sq mi)
(1923-1985)

	Mean		Maximum		Minimum	
	Inches	CFS	Inches	CFS	Inches	CFS
January	1.18	156	2.77	368	.29	39
February	1.20	177	3.74	550	.27	39
March	2.39	317	9.21	1,222	.49	65
April	4.68	642	9.76	1,338	1.67	229
May	2.68	355	5.75	763	.59	78
June	1.35	185	3.60	493	.44	60
July	.90	119	4.96	658	.28	37
August	.72	96	2.95	392	.19	25
September	.69	94	4.31	591	.23	31
October	.90	120	3.47	461	.26	35
November	1.18	162	4.08	560	.26	36
December	1.35	179	4.57	607	.35	46
Annual	19.22	216	31,94	359	7.47	84

5. FLOOD HISTORY

a. General. There are historical references to floods on the Mascoma River dating back to when the vicinity was settled, about 1750; but there is little information available as to the magnitude of floods prior to the early 1900's. The March 1936 event is the greatest known flood on the Mascoma River. The ten greatest floods that have occurred since August 1923 are shown in order of magnitude in Table 6.

TABLE 6

TEN HIGHEST KNOWN FLOODS
MASCOMA RIVER AT MASCOMA, N.H.
Zero of Gage = 740.0 feet NGVD
(D.A. = 153 sq. mi.)

Date of Crest	Elevation at Gage (ft NGVD)	Peak Discharge (cfs)
March 19, 1936	747.50	5,840
March 27, 1953	746.03	4,880
Sept. 22, 1938	746.85	4,400
July 1, 1973	745.75	4,260
June 1, 1984	745.72	4,200
April 19, 1933	746.67	3,630
April 1, 1987	745.42	3,600
March 30, 1925	746.25	3,540
April 13, 1934	746.55	3,500
Nov. 5, 1927	745.94	3,230

It is noted that the recorded peak flow rates relative to other watersheds are relatively small. Peak flows are modified by storage in Mascoma Lake along with a possible desycrinization of peak flows due to the numerous swamps and waterbodies. Records do not show any history of seriously damaging floods in this basin. The Mascoma basin has been relatively free from such occurrences and whenever extraordinarily high waters have occurred, the damages have been low in comparison with figures for other basins.

Following are descriptions of five large floods which have occurred in the Mascoma River basin.

b. March 1936 - The flood of March 1936 was the result of four distinct storm centers passing over the northeastern part of the country between March 9 and 22. The total precipitation for this period ranged from four inches in eastern Massachusetts up to 16 inches in north-central New Hampshire, with the first of this precipitation falling on a snow cover which had a water content ranging from five to ten inches in northern New England and less in southerly portions. During the March 9-22 period the precipitation at Hanover, New Hampshire totalled 4.6 inches. The snow cover in the watershed had an estimated water content at the beginning of the period of about five inches. The ground had frozen early in the winter, and the rain which fell during the period March 9-22 was accompanied by unseasonably high temperatures. These factors combined to give many New England rivers their greatest flood peaks to date. At the Mascoma gage the river rose to elevation 745.5 feet NGVD (stage 5.5 feet) on March 14, dropped back to elevation 744.5 feet NGVD on the 16th, only to crest at elevation 747.5 feet NGVD on March 19, before receding to elevation 744.5 feet NGVD on the 25th. Stage comparisons indicate that the flood level at the Hanover Street Bridge crested at about elevation 582 feet NGVD. In general, the river rose three to five feet above flood stage.

c. September 1938 - A tropical hurricane which was first located about 1,000 miles east-southeast of Miami, Florida, on September 18 moved up the coast, striking New Haven, Connecticut at 3:50 p.m. on the 21st, and passed through the Lebanon area at about 6:20 p.m. Combining with a low pressure trough which had moved slowly across the country from the west, it produced torrential rainfall in New England between the 18th and 22nd. In addition, heavy rainfall between the 12th and 15th caused by the low pressure trough resulted in high antecedent conditions. At Hanover 2.6 inches of rain fell between the 18th and 22nd. The river at the Mascoma gage rose to elevation 746.8 feet NGVD on the 22nd before receding to elevation 743.7 feet NGVD on the 26th. The flood level is estimated to have crested at about elevation 580 feet NGVD at the Hanover Street Bridge, being generally about two to three feet above flood stage.

d. March 1953 - The flood of March 1953 was caused by four separate coastal storms, combined with an upper level slow-moving "low" extending over the northeastern section of the country, and unseasonably high temperatures after March 11. A total of 1.7 inches of rain fell at Lebanon between the 13th and 16th, followed by 2.7 inches of rainfall between the 24th and 31st. Fortunately, snow cover was considerably below normal, otherwise flooding would have been much greater. At the Mascoma gage the river rose to about elevation 743.5 feet NGVD on the 18th, dropped to elevation 743.0 on the 24th, and then rose to elevation 746 feet NGVD before receding to about elevation 742.5 feet NGVD on April 3. A corresponding flood level of about 581 feet NGVD was attained at the Hanover Street Bridge. The crest was generally three to four feet above flood stage.

e. May/June 1984. During the last week of May a large slow moving storm system passed through New England bringing rainfall on Memorial Day that continued for approximately a week. Precipitation amounts varied from eight to nine inches in Massachusetts, Connecticut, and Rhode Island to about five to seven inches in New Hampshire and Vermont.

This was a major flood event along the main stem Connecticut River, with an estimated return frequency of about once in 50-years in southern Massachusetts and Connecticut; it has only been exceeded by the September 1938 and March 1936 floods since records were initiated by the earlier settlers in the 17th century.

At the USGS gage below Mascoma Lake a peak discharge of 4200 cfs was recorded. At this location the river rose to about elevation 745.7 feet NGVD on 31 May 1984 and then receded to about elevation 742.0 feet NGVD on 7 June 1984. The resulting high water crested several feet above flood stage at Mahan Flats. Total rainfall recorded at Hanover, N.H. was over 6.0 inches for the period of 27 May-2 June.

f. March/April 1987. This most recent flood began on 31 March 1987 when the New England region began experiencing heavy rainfall. However, the Mascoma River Basin experienced only about two to three inches of rain for the 31 March - 8 April period. Because of the relatively small amount of rain in the basin and the modifying effects of Mascoma Lake, the Mascoma River did not experience any significant flooding. The river crested at 572.0 feet NGVD at the Hanover Street Bridge. Total rainfall recorded at Hanover was 2.96 inches over the period 31 March - 8 April.

6. FLOOD FREQUENCIES

Peak discharge frequencies were developed for the Mascoma River by analysis of records from the long term gaging station at Mascoma, New Hampshire (located downstream of Mascoma Lake) and the discontinued gaging station at West Canaan, NH (located about two and one-half mile upstream of Mascoma Lake). USGS gaging station 01150500 at Mascoma Lake has a drainage area of 153.0 square miles and a period of record of 63 years (1924-1987). USGS gaging station 01145000 at West Canaan has a drainage area of 80.5 square miles and a period of record of 40 years (1938-1978). The peak annual discharges were analyzed in a log Pearson Type III distribution in accordance with the guidelines in WRC's Bulletin 17B.

A discharge-frequency curve, shown on plate 2, using an adopted skew of 0.3 was computed for the Mascoma gaging station with the following statistics: mean log 3.2721 and standard deviation 0.1980. The discharge frequency analysis included an estimate of the 1987 peak flow (3600 cfs). As can be seen on the developed discharge frequence curve, the 100 year discharge is 6400 cfs (41 csm). A 100 year peak flow rate of 41 csm, relative to other watersheds in New England is not exceeding large. As stated previously this gaging station is located downstream of Mascoma Lake and flows are effected by storage in the lake. The resulting discharge frequencies at Mascoma Lake (153 square miles) were transferred downstream to Lebanon (approximately 190 square miles) by ratio of their respective drainage areas to the .7 power. This discharge frequency curve is shown on Plate 2.

A discharge frequency curve, shown on plate 3, using an adopted skew of 0.2 was computed for the West Canaan gaging station with the following statistics: mean log 3.1895 and standard deviation 0.1777. Unfortunately this gage was discontinued in 1978, and discharge values for the 1984 and 1987 flood events are not available.

7. FLOOD PROBLEM AREAS

a. General. Following the March/April 1987 flood a reconnaissance of the watershed was made starting from the mouth of the Mascoma River proceeding west to Lebanon and Mascoma Lake. From there the inspection team heading further west to Enfield and West Canaan and then northward along the Mascoma River to the headwaters of the watershed. Results of these field observations and discussion with local residents and town officials indicated two flood problem areas within the watershed along the Mascoma River, and a potential flood problem area at the Route 4 crossing in Canaan.

b. Mahan Flats - Mahan Flats, located in Lebanon, is a mixed use area (residential, commercial, and industrial) located about three miles upstream from the mouth of the river.

c. Riverdale - Riverdale, also in Lebanon, is a residential area containing about 30 homes in the floodplain between interstate 89 and the river located approximately 2,000 feet upstream from Mahan Flats.

c. Route 4, Canaan - The flood problem area is located just west of Goose Pond Road where the Mascoma River crosses Route 4. There are about four homes, a general store, and a gift shop located in the area.

8. STAGE FREQUENCY CURVES

Stage-frequency curves were developed at Mahan Flats, Riverdale, and the Route 4 crossing in Canaan. The curves were developed from discharge-frequency curves based on analysis of records at the two USGS gages and stage discharge relationships developed from profiles in the 1972 Flood Plain Information report and the various flood insurance studies. Where available, historic flood levels are shown on the curves (see plates 4 and 5).

9. FLOOD CONTROL ALTERNATIVES

a. Upstream Flood Control Reservoirs. As a possible basin-wide solution, it was attempted to locate feasible flood control reservoir sites. The Mascoma River watershed has a number of reservoirs and lakes most of which have extensive shorefront development. Therefore, many of the potential reservoir sites have been developed and modification of their operation in the interest of flood control is viewed as impractical (see section 10 for further discussion). A cursory review of the remainder of the watershed was undertaken to locate possible reservoir sites. The Mascoma River has a total drainage area of about 194 square miles; therefore, any potential flood control reservoir must be able to control sufficient drainage area to significantly reduce downstream peak floodflows. As stated previously, a prominent feature in the watershed is Mascoma Lake which has a drainage area of 153 square miles or about 80 percent of the total Mascoma River watershed. The lake formerly provided water for downstream hydropower plants but is now used mostly for recreation. Other existing reservoirs above Mascoma Lake, namely Goose Pond, Clark Pond, Crystal Lake (Canaan Center), and Crystal Lake (Enfield) have a total of approximately 60 square miles of drainage area. These reservoirs also have extensive shorefront development and would not be effective as flood control reservoirs.

As part of the New England - New York Inter-Agency Committee (NENYIAC) studies on flood control reservoir (West Canaan) was located within the Mascoma River watershed. This site, with a drainage area of 80 square miles is situated on the Mascoma River, 19.5 miles above its confluence with the Connecticut River, and about 1 mile upstream from West Canaan New Hampshire. Development of the site for flood control purposes would require considerable land taking (1600 acres) from about elevation 850 to 900 feet NGVD and would reduce peak discharges at Lebanon about 50 percent. At the time of the NENYIAC report it was concluded that development of this site for flood control would be uneconomical due to highway and railroad relocation. A brief attempt to locate other potential reservoir sites was explored.

The only remaining tributaries with significant drainage areas are Indian River and Orange Brook (total drainage area = 34.7 square miles) and the Mascoma River above Canaan Center (total drainage area = 23 square miles). Indian and Orange Brook are located upstream of Canaan and to provide a reasonable amount of flood control storage (equivalent to six inches of runoff from their upstream watersheds) a dam would have to be constructed at their confluence. A dam approximately 35 feet high and 1500 feet in length would have to be constructed at the confluence of the two streams (also two upstream 20-25 foot high dikes would be needed to contain the reservoir). Construction of this dam and dikes would enable utilization of lands up to elevation 980 ± ft. NGVD for flood control storage. Total land area up to elevation 980 ft NGVD would be about 280 acres. It is estimated that this flood control reservoir would reduce peak discharges at Lebanon about 25 percent; however, relocation of several roads, one major highway, and the taking of many residences would be required. A dam constructed on the Mascoma River above Canaan Center would be approximately 30-35 feet high and about 2500 feet long and would provide 6.0 inches of runoff from it's upstream watershed. Construction of this dam would enable utilization of lands up to elevation 990 ± ft. NGVD for flood control storage and would reduce peak discharge at Lebanon about 20 percent. Total land area up to elevation 990 ft NGVD would be about 250 acres. The relocation of several roads and the taking of some residences would be required. It is estimated that flood control reservoirs at Indian/Orange Brook and Mascoma River at Canaan would reduce stages at Lebanon for a recurrance of the 1984 flood about 0.5 foot and 0.3 feet respectively. These reservoirs however would have high real estate and construction costs, as well as environmental impacts and are viewed as economically unfeasible.

b. <u>Channel Improvements - Lebanon (Mahan Flats and Riverdale)</u>. Channel improvements in Lebanon have been investigated by the Corps of Engineers in the past. Detailed analysis was somewhat limited, however it was determined that the Mascoma River in Lebanon has a restricted channel capacity in areas and flooding does occur, particularly in low lying floodplain areas. The present river channel is generally less than 100 feet in width and six to eight feet in depth. Estimated safe channel capacity through this area varies from 2,000 to 3,000 cfs as compared to the estimated 100-year discharge in the order of 7,000 cfs. While the existing channel approximates 600 to 1,000 square feet in cross sectional flow areas, improvements necessary to provide an estimated 100-year level of protection would require doubling the flow area, whether accomplished through channel widening or by diking adjacent to problem areas. Channel improvements would require over a mile of widening, straightening and possible bridge reconstruction.

Recently the city of Lebanon contracted Rivers Engineering Corporation of Manchester NH to evaluate alternative channel improvement schemes in Lebanon (Mahan Flats). Rivers Engineering obtained extensive river cross section surveys and utilized the HEC-2 computer program to compute flood profiles. A base flood discharge of 7000 cfs (100 year) was used to screen alternatives. Various alternatives were analyzed and results were presented in a report titled "Channel Improvement Study, Mascoma River, Lebanon, New Hampshire, City of Lebanon Department of Public Works," dated August 1988. This report was used by the city as a screening tool for suggested improvements to flood control and not as construction work to be accomplished. The recommended alternative consists of channel modifications as follows:

(1). Improved rectangular channel with a bottom wide of 75 feet and vertical side slopes. This would require deepening and widening a section of river starting about 300 feet upstream of the Hanover Street Bridge. This improvement would continue for about 650 feet and would require modifications to a 12 inch VC sewer line and an existing sewer siphon.

(2). Improvements would continue with dredging and widening the channel from approximately 1200 feet upstream of the Hanover Street Bridge to 200 feet downstream of the Spencer Street Bridge, a total distance of about 2500 feet. The improved channel would have a trapezoidal cross section with a 100 foot bottom width and 2 to 1 side slopes. This improvement would result in improved channel inverts from 561.0 to 571.0 feet NGVD with resulting required excavations of from 1 to 5 feet. The improvement would also require modification to another existing sewer siphon. To provide a 100 year level of protection with freeboard, a 3 foot high dike would be required on the left bank of the river channel (this would most likely be a freeboard dike). Rivers Engineering states that the above improvements would lower the 100 year flood elevation 4 to 4.5 feet. While Rivers assumed a dike section to obtain a full 100 year level of protection, no interior drainage facilities were recommended. Therefore, assuming drainage could be intercepted at the railroad and diverted around the dike, interior drainage area would be reduced to about 40 acres. Assuming a pumping rate of 0.2 inch per hour a 8 cfs pumping capacity would be required.

c. Channel Improvements (Route 4, Canaan). Channel improvements to protect the few homes and two stores in this area could be accomplished by channel excavation, dikes, and/or walls. However, the cost of any of these improvements would outweigh benefits realized from the flood protection of the few structures. Therefore, it is considered economically unfeasable for structural improvements at Route 4, Canaan.

10. EXISTING RESERVOIRS

A. General. Questions have been raised on the possibility of increasing the flood control effectiveness of existing reservoirs within the watershed. Essentially 100 percent of storage in the watershed is located in Mascoma Lake and impoundments upstream of Mascoma Lake. A review of the watershed map (Plate 1) reveals that the majority of the impoundments upstream of Mascoma Lake are located in the headwaters of small tributaries with relatively small drainage areas. For the most part these appear to be small recreational ponds with probably little impact on peak discharges. Mascoma Lake however, with a surface area of 1200 acres and recrational storage capacity of 8300 acre-feet and a drainage area of 153 square miles can have a modifying effect on peak flows. This is demonstrated by a review of the recorded peak discharges along the Mascoma River at West Canaan (80.5 sq. mi.) and at Mascoma (153 square miles). The gage at West Canaan is located upstream of Mascoma Lake and it's watershed has several small impoundments located in the headwaters. The period of record at this gage is from 1938-1978 with the largest recorded flood flow of 4310 cfs (55 cfs/square mile) in September 1938. This same flood event recorded at the gage directly downstream of Mascoma Lake had a peak discharge of only 4400 cfs (29 cfs/square mile). Two other significant flood events where data is available at West Canaan and Mascoma are in March 1953 and July 1973. Peak discharges at West Canaan were 3780 cfs (47 csm) and 3150 cfs (39 csm) respectively. Recorded discharges downstream of Mascoma Lake were 4880 cfs (32 csm) and 4260 cfs (28 csm) respectively for the same two flood events. As can be seen peak flow rates downstream of the lake are 30-50 percent less than those recorded upstream. Therefore, Mascoma Lake is currently reducing peak discharges either by having storage available prior to the flood event, through the use of surcharge storage or by desycronizing peak flows. Requirements necessary to further reduce peak flows by utilizing Mascoma Lake were briefly explored.

b. Reregulation of Mascoma Lake. Although the Mascoma River watershed has many lakes and reservoirs, the only project which has the potential to reduce peak flood flows by a change in operational mode is Mascoma Lake reservoir.

Mascoma Lake has a total drainage area of 153 square miles and a total storage capacity of 8,330 acre-feet (approximately 1.0 inch of runoff). Present operating procedures are to draw the pond down 4.0 feet in the winter and early spring and refill again in late spring. Therefore, this procedure currently has an effect on peak discharges in the watershed. The total storage capacity in Mascoma Lake is relatively small (only about 1 inch of runoff). Assuming 100 percent of this storage capacity available for flood control, it is estimated that significant reduction would occur for the more frequent flood events. However, during a major flood event the lake most likely would fill very quickly and significant reduction to peak flows probably would not occur.

If the reservoir was drawn down about four feet and maintained at that level, during all seasons, only about 0.5 inch of runoff for flood control storage could be obtained. This procedure would have little impact on flooding and is viewed as impractical due to heavy recreational use. Because of the relatively small storage capacity of Mascoma Lake, use of this impoundment for flood control would be quite limited.

11. SUMMARY/CONCLUSIONS

a. General. The Mascoma River experienced significant flooding in 1984 and minor flooding in 1987. Two significant flood problem areas have been identified, the Mahan Flats and Riverdale sections of Lebanon, New Hampshire. While the flooding in New England from the 1987 flood event was widespread there were some street and basement flooding in Lebanon with a minimum of properties experiencing first floor flooding.

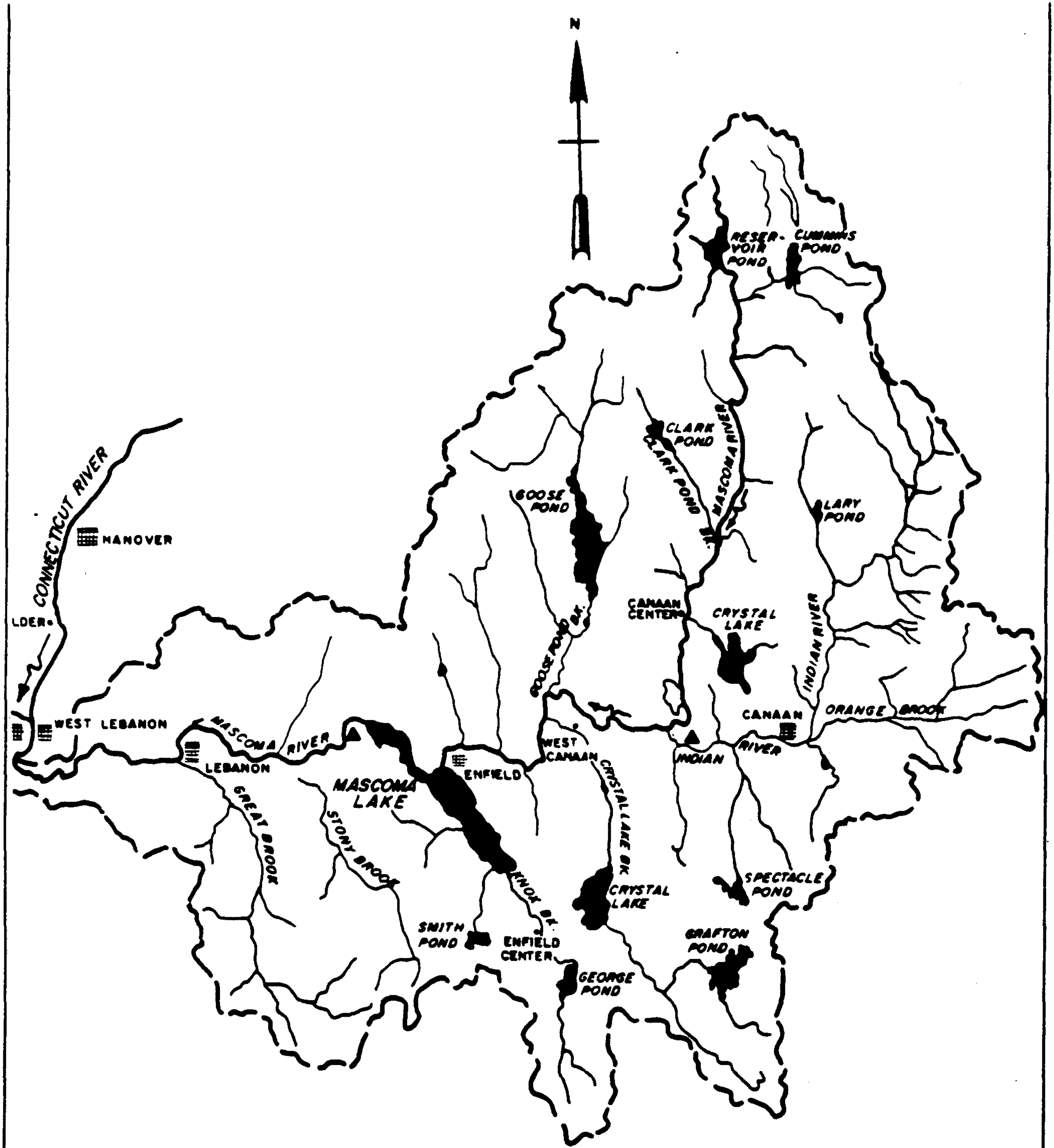
b. Structural Improvements.

(1). Dikes/Walls. Protection of the commercial and residential areas of Mahan Flats and Riverdale would require substantial dikes and walls, interior drainage facilities and possible bridge replacements. It appears from preliminary economic analysis that the cost of such improvements would outweigh benefits.

(2). Channel Improvements. Channel improvements as proposed by Rivers Engineering could lower flood levels in Mahan Flats 4 to 5 feet. Rivers Engineering has done a detailed analysis with an appropriate design condition of 7000 cfs (100 year) and has proposed about a 3 foot high dike on the left bank to obtain a full 100 year level of protection. If such a dike were constructed by the Corps of Engineers, interior drainage facilities would be required (see paragraph 9b).

(3). Flood Control Reservoirs. Potential flood control reservoirs sites were located upstream of Marcoma Lake (see Section 9a). Development of these sites would require significant land taking and construction of dams 30-50 feet high.

c. Non Structural Improvements - Flood Warning. A flood warning system was briefly evaluated for the flood prone areas of Mahan Flats and Riverdale; however, with the short lead time and improvements needed at Mascoma Lake, it appears unfeasible. For further discussion of flood warning see main report of the Mascoma River Reconnaissance Study.

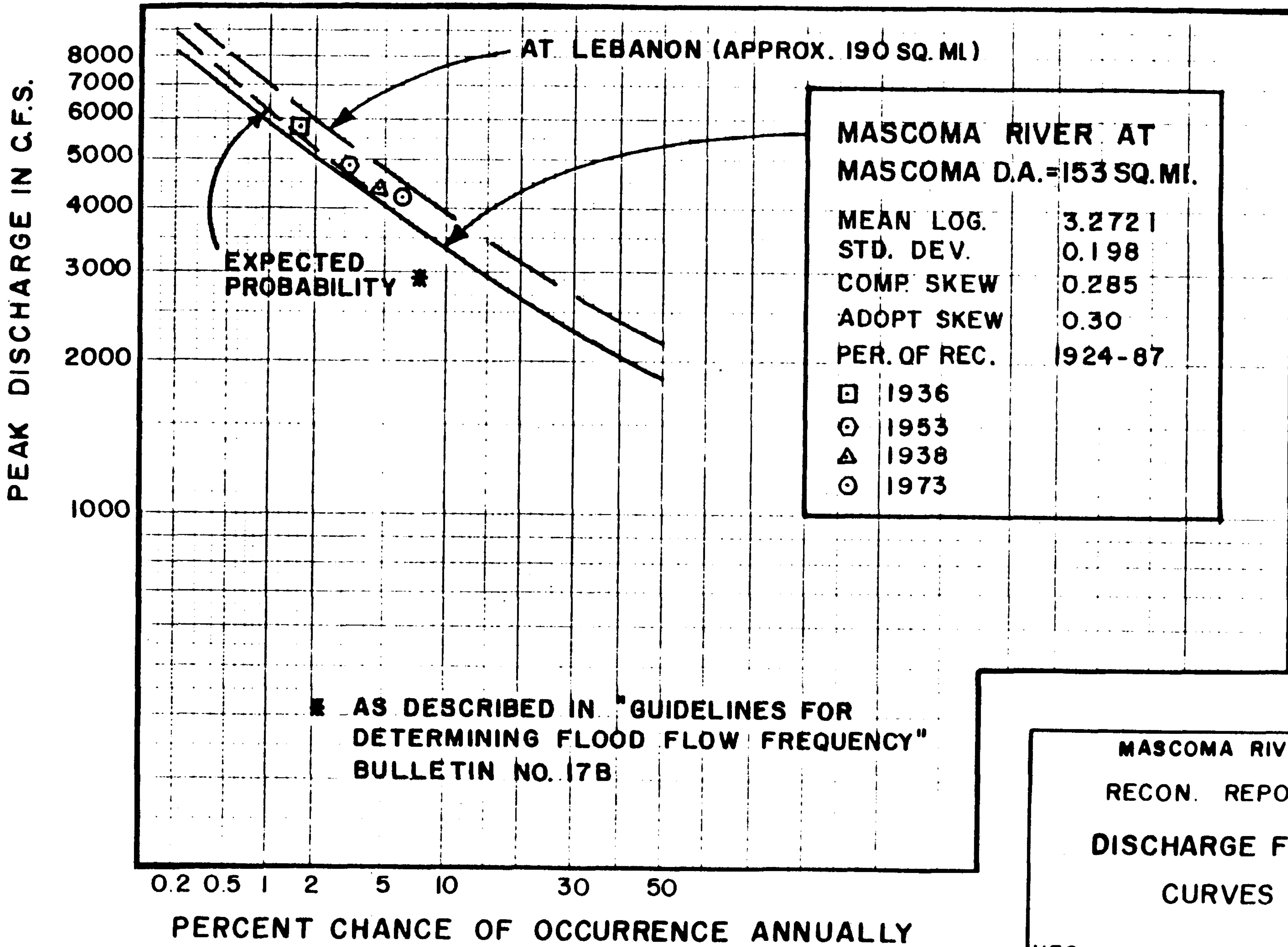


LEGEND

▲ U.S.G.S. GAGING STATION

FLOOD PLAIN INFORMATION
MASCOMA RIVER
LEBANON NEW HAMPSHIRE

PLATE I



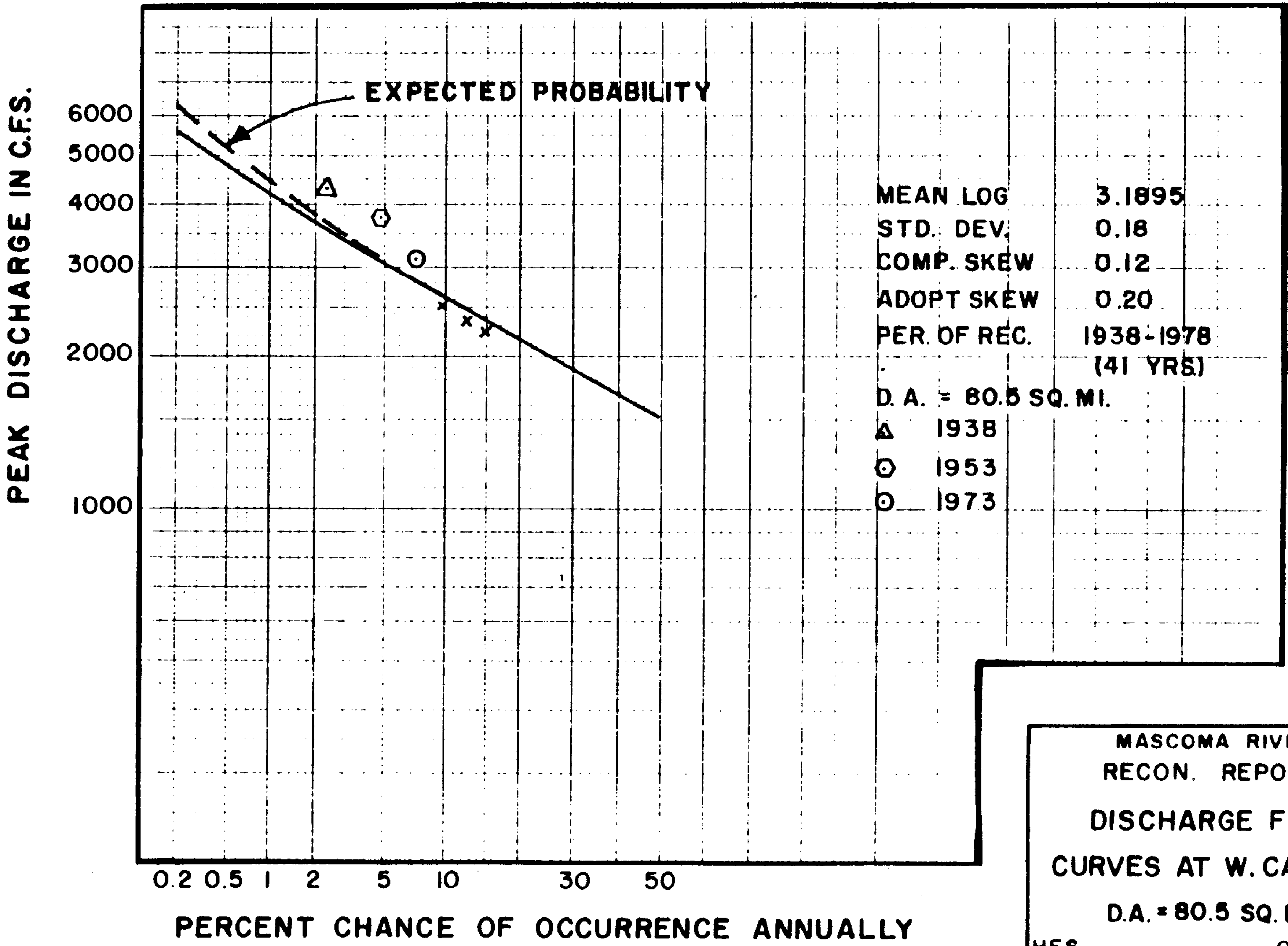
MASCOMA RIVER

RECON. REPORT

DISCHARGE FREQ.
CURVES

HES OCT. 1988

PLATE 2



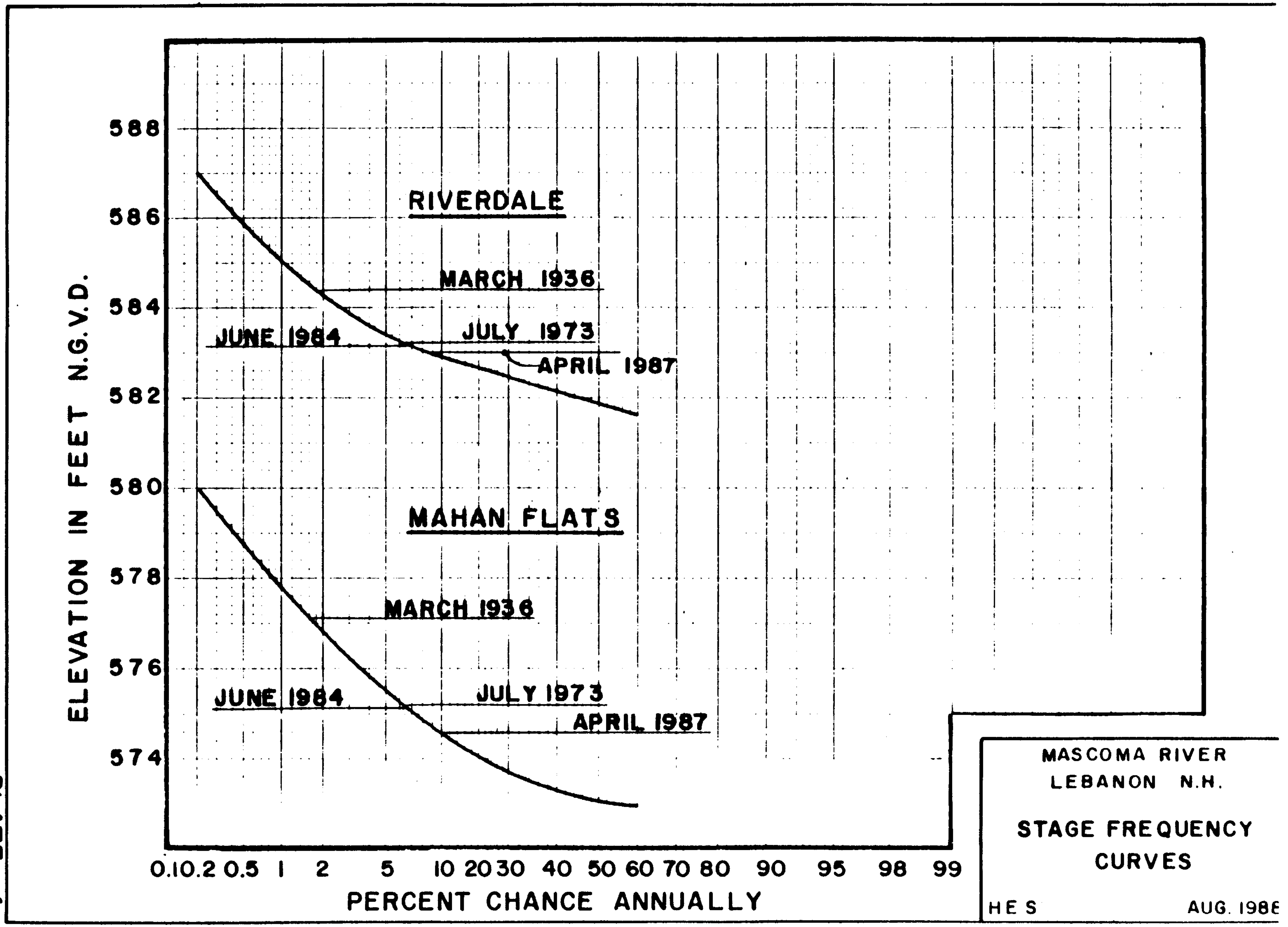
MASCOMA RIVER
RECON. REPORT

DISCHARGE FREQ.
CURVES AT W. CANAAN

D.A. = 80.5 SQ. MI.

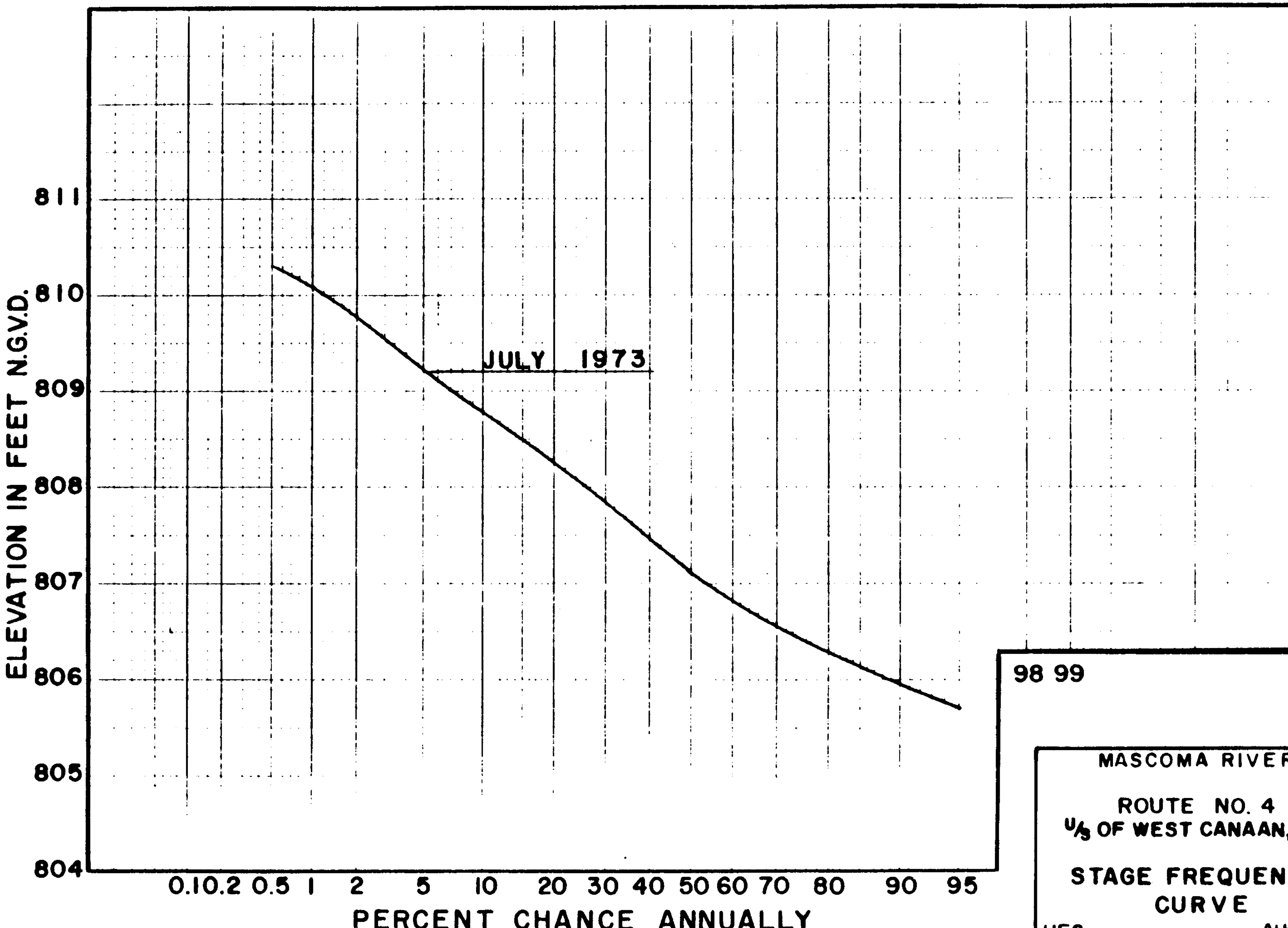
HES OCT. 1988

PLATE 3



RIVERDALE
MARCH 1936
JUNE 1984
JULY 1973
APRIL 1987
MAHAN FLATS
MARCH 1936
JUNE 1984
JULY 1973
APRIL 1987
ELEVATION IN FEET N.G.V.D.
588
586
584
582
580
578
576
574
0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99
PERCENT CHANCE ANNUALLY
MASCOMA RIVER
LEBANON N.H.
STAGE FREQUENCY
CURVES
HES
AUG. 1988

PLATE 4



MASCOMA RIVER

ROUTE NO. 4
U/S OF WEST CANAAN, N.H.

STAGE FREQUENCY CURVE

HES AUG. 1988

APPENDIX B

ECONOMIC ANALYSIS

Introduction

The purpose of the economics section is threefold. The first is the specification of the flood loss potential as relates to the existing without project condition in the Mascoma Basin. This will be accomplished by delineating significant flood damage centers, identifying floodplain activities and estimating recurring losses and expected annual losses. Secondly, inundation reduction benefits will be estimated for structural and nonstructural improvement plans. Secondly, inundation reduction benefits will be estimated for structural and nonstructural improvement plans. Thirdly, each plan's measure of economic justification will be determined through calculation of a benefit/cost ratio. Net benefits will be presented for plans with a benefit/cost ratio greater than one. The economic analysis is performed at the reconnaissance level of detail. Annual losses and benefits reflect the October 1988 level of prices.

Flood Damage Survey

Geographically, flood losses are concentrated in 3 distinct damage centers in the basin, namely Mahan Flats and Riverdale in Lebanon and an area of Rt. 4 in Canaan. A flood damage survey was performed in these damage centers during April 1988 by a flood damage evaluator from the New England Division. At each floodprone structure and site flood losses were estimated, in one-foot increments, beginning at the elevation at which discernable losses are first incurred up to the elevation of a rare and infrequent (500 year) event. Ground and first floor elevations for most properties were obtained. Interviews were conducted for commercial, industrial and public activities. For residential properties, use of sampling, typical loss profiles by type of home and minimal interviewing were employed. Both physical and non-physical losses were estimated. Also, the cost of emergency services and damages to transportation, communication and utility systems were obtained where possible.

Recurring Losses

Recurring losses are those potential flood related losses which are expected to occur at various stages of flooding under present day development conditions. As the final output of the flood damage survey process, recurring losses are expressed as an array of dollar losses, in one foot increments, from the start of damage to the elevation of the rare (500 year) event. The number and type of properties, in each of the 3 damage centers, for which recurring losses were estimated is as follows.

Properties - Number and Category

	Mahan Flats	Riverdale	Canaan
Commercial	9	1	1
Residential	26	58	3
Public	3	-	-
TOTAL:	38	59	4

Total recurring losses for selected flooding events in the 3 damage centers under investigation are found below.

Recurring Losses - By Event

Location	10 Year	50 Year	100 Year	500 Year
Mahan Flats	$ 54,700	$217,600	$306,200	$ 745,700
Riverdale	106,700	240,100	305,300	691,300
Canaan	130,400	198,600	218,600	230,600
TOTAL:	$291,800	$656,300	$830,100	$1,667,600

Annual Losses

The purpose of estimating annual losses is to measure the severity of potential flooding on an "expected annual" basis in each damage center. Annual losses are the integration and summation of two sets of data at each damage location. Recurring losses for each flood elevation (event) are multiplied by the annual percent chance of occurrence that each specific flood elevation (event) will be reached. The effectiveness of each alternative flood reduction plan is measured by the extent to which it reduces annual losses. Annual losses in the 3 damage centers are found below.

Location	Annual Losses
Mahan Flats	$ 26,300
Riverdale	37,900
Canaan	47,200
TOTAL:	$111,400

Improvement Plans and Benefit Estimation Methodologies

Both structural and nonstructural were evaluated for economic justification. The structural plans for which benefits were estimated are: a diversion tunnel, dikes and floodwalls and channel modifications. Nonstructural plans that were evaluated are: first floor raising, small walls or dikes, and relocation. Benefits are estimated for diversion plans by calculating annual losses prevented up to the design level of protection. Benefits for dikes and walls are also annual losses prevented up to the level of protection (elevation) plus 50 percent of losses in the freeboard range. For channel modifications, annual losses are calculated for the natural and modified channel conditions. The difference in the two sets of losses is the benefits to the modification plan. Benefits for the raising of first floors are estimated by comparing annual losses to each structure with the first floor at the existing elevation versus the losses with the first floor raised one foot above the 100 year flood level. Benefits are the difference in annual losses. Relocation plans seek to remove the damage potential from the floodplain by relocating the inhabitants and their personal property. Benefits for relocation are specialized and discussed at length further in this report.

<u>Diversion Plan</u>

The diversion plan, designed to convey a 100-year floodflow from upstream of Riverdale to downstream of Mahan Flats would eliminate all damages up to the 100 year event. Benefits would be $33,300 for Riverdale and $20,500 for Mahan Flats for a total of $53,800. With an annual cost of $945,000 the benefits/cost ratio is 0.06 to 1 and the plan is not economically justified.

<u>Dikes and Floodwalls</u>

<u>Mahan Flats</u> - The 2800 foot earth dike for this area was designed to control a 100 year event. Benefits are annual losses prevented up to the 100 year flood elevation (578') plus 50 percent of the 3 feet of freeboard for a total height of 579.5'. Benefits total $23,000 annually. With an annual project cost of $90,000 the benefit/cost ratio is 0.3 to 1 and the plan is not economically justified. A system of dikes and walls to protect this same area to the same elevation will yield the same amount of benefits ($23,000). However, with an annual cost of $128,000 and resulting benefit/cost ratio of 0.2 to 1 this plan is also not economically justified.

<u>Riverdale</u> - A combination of earth dike (675') and floodwall (675') was designed to protect the Riverdale area against a 100 year flood event. Benefits were calculated to elevation 586.5 and total $36,000 on an annual basis. The annual cost for this plan is $70,000 and the benefit/cost ratio is 0.5 to 1. The plan is not economically feasible.

Channel Modifications

The recommended channel modifications, which include deepening and widening of 2,500 feet in the Mahan Flats area, would reduce the 100 year flood levels by approximately 4.5 feet. The benefits to these modifications are a $17,300 reduction in annual losses versus the existing condition of the channel. However, the annual cost of the improvements is $260,000 which results in a benefit/cost ratio of 0.07 to 1 and a lack of economic justification.

Raising First Floors

Benefits for this improvement measure are the difference in annual losses for each structure with the first floor at its existing elevation versus the elevation after raising the first floor to one foot higher than the 100 year flood level. Mahan Flats - Total annual benefits which accrue to raising the first floors of the 26 residential structures in this area amounts to $10,300. With an annual cost of $58,000 and a benefit/cost ratio of 0.2 to 1, the plan is not economically justified. Riverdale - Benefits were estimated for raising the first floor of 58 residences and totalled $22,700. The plan for this area was also not justified with an annual cost of $126,000 and a benefit cost ratio of 0.2 to 1.

Small Walls or Dikes

Benefits are estimated for small walls and dikes in the identical manner used for large walls and dikes. To identify candidate properties for small wall and dike plans recurring losses were examined. The only property which exhibited signficant damage potential was the Emerson Greenhouse. Recurring losses for this property are $6,500 for a 10-year event, $55,400 for a 50-year event and $66,500 for a 100-year event. Expected annual losses are $3,400. The 900 foot long small dike for this property would produce annual benefits of $3,000, but with an annual cost of $18,000 and a benefit/cost ratio 0.2 to 1, the plan is not economically justified.

Relocation

Permanent relocation is the complete evacuation of existing activities to locations not susceptible to flood damage. Relocation may consist of: (i) the physical movement of structures to new locations, (ii) the demolition of structures at floodprone locations and the construction of new buildings at different locations, or (iii) the demolition of structures and provision of funds for purchase of new buildings. Benefits for permanent relocation are classified into five categories: (1) the value of the new use of the vacated land, (2) reduction in damage to public property, such as roads and utilities, (3) reduction in emergency costs, (4) reduction in the administrative costs of disaster relief and (5) reduction in the flood insurance subsidy. No benefit is taken for the reduction in private flood damage because it is assumed that expected flood losses are for the most part, reflected in lower property values of floodplain properties. In the benefit cost statement, because the reduced property values lower the costs of relocation, it would be double counting to also include reduced physical damages in the benefits. Of the 5 benefit categories stated above, the first, the value of the new use of the vacated land is critical to the economic justification of a relocation plan. The land must have considerable value in its new use. The land in Mahan Flats, Riverdale, and Canaan was not projected to have high value after implementation of a relocation plan. Its most probable use would be park or recreation land. Because of its limited size, geographical location and floodprone nature it would not become highly valued, income-producing land such as agricultural land. In reference to the other four benefit categories, benefits were also expected to be minimal based on the existing level of annual losses in relation to the number of properties. Economic justification for relocation is extremely doubtful when considering the cost to relocate 101 structures versus the benefits for lower land values, minimal public savings (benefit categories 2, 3, and 4) and minimal reduction in the flood insurance subsidy (category 5) due to property losses averaging less than $700 annually.

APPENDIX C

HISTORIC AND ARCHAEOLOGICAL RESOURCES

HISTORIC AND ARCHAEOLOGICAL RESOURCES

Prehistoric period (11,000 years before present [B.P.] to c. 1600 A.D.)

There are no recorded archaeological sites dating from the prehistoric period within the project study area. However, based upon information available from other nearby river basins, preliminary predictions can be made for site potential or sensitivity within the Mascoma River Basin. Information was gathered from site records at the New Hampshire and Vermont State Historic Preservation Offices (SHPO), and from numerous published and unpublished sources.

The Mascoma River is a tributary of the Connecticut River. The Connecticut River has been used since early post-glacial times as a major north-south transportation route by native Amerindian groups. Tributary rivers and streams allow easy access to the adjacent uplands, where resources such as stone for tools (felsite, quartzite, steatite), and upland flora and fauna were available. Evidence of Amerindian use of the river valleys and uplands, in the form of occupation sites, fishing stations, growing fields, petroglyphs, and burial grounds, has been encountered along the entire length of the Connecticut River Valley eroding out of the river bank, or in plowed fields along higher river terraces. Somewhat smaller sites, probably representing such activities as stone quarrying (for tool manufacture), or specialized hunting or collecting camps, as well as seasonal occupation sites have been encountered along smaller tributary rivers, streams, and scattered ponds in the uplands. Upland wetlands, which attract a variety of game, may also be the focus of prehistoric hunting activity. Rock shelters, or small caves represent another resource used periodically by native groups.

Land use, and consequently the size, nature and distribution of sites has varied over the millennia, as climate, vegetation and animal species have changed. Generally, we have come to expect to find prehistoric sites on fairly level landforms, near a source of water (river, stream, pond, spring, swamp), or other prominent resource (argillite, felsite, quartzite, steatite, clay deposit), and on fairly well-drained soil. Paleo-environmental reconstructions become important to locate sites that once would have had these characteristics, but have since been altered because of changes in water courses or water tables, or other factors. Changes in social organization can also affect site size and distribution. During the Indian Wars of the 17th and 18th centuries, for instance, some sites were located on high bluffs or terraces for defense, not for convenience.

Given the great intensity of prehistoric occupation that has been detected along the Connecticut and many of her tributaries, we would expect that the Mascoma River Valley was exploited by Amerindian groups for at least the last 8-10,000 years. Sites may have a wide distribution in many micro-environemts. The river would probably have been used as a major highway, with streams and side valleys being side avenues to access the uplands. Sites are very likely to be located along the banks of the river, especially at stream junctions.

Unfortunately, natural stream meandering and flood scouring, as well as historic activities such as commercial and residential development, dam and millpond construction, and rip-rapping may have already obscured a large portion of the archaeological record. Long stretches of the river bank have been disturbed in some way. This makes any remaining site more valuable for discovering and interpreting the past. Any structural solutions to flooding, such as dikes, walls, or rip-rapping could affect as yet undiscovered archaeological sites. Professional archaeological surveys would be required to document disturbed and undisturbed areas before such structures were constructed. Non-structural solutions, such as floodproofing buildings, or creating flood-warning systems, would be unlikely to affect undisturbed prehistoric archaeological sites.

Historic period - Lebanon

Lebanon, New Hampshire, is located at the junction of two valleys. The narrow Mascoma Valley, running in an east-west direction, and Great Brook and Great Hollow extending in a north-south direction. Because the valleys are fairly narrow, and are hemmed in with steep hills on all sides, development has focused on the River as a transportation route, and as a source of power.

The charter of Lebanon, New Hampshire was granted in 1761, one of the many charters granted in that year by Benning Wentworth, Governor of New Hampshire. In October of that year, the proprietors of the charter began to divide the land into 100 acre lots. Permanent settlement did not commence until a bridle path was completed along the Connecticut River, linking Lebanon to Fort No. 4 in Charlestown in 1763. By 1767, Lebanon had a population of 162.

In 1773, Lebanon had a recorded population of 295, and by 1775, the population had expanded to 347. There were a variety of commercial enterprises in the town and several of these were located on the Mascoma River or its tributaries. A Major John Slapp had a grist mill on the Mascoma and Davison's lumber mill was located near the Hubbard Bridge, also on the river. The town could boast of having several shoemakers and joiners, as well as a new meeting house, constructed sometime after 1772 for religious and civil meetings. However, the town did not not contain a store or place of trade. Many of the settlers were originally from Connecticut, and most of their trading took place down the Connecticut River in Hartford, or to a lesser extent at Fort Number 4 in Charlestown, New Hampshire.

There were several new roads built through Lebanon in the 18th century. Most of these roads were not main thoroughfares connecting Lebanon with the market towns of Hartford and Boston. Rather the roads were constructed to improve transportation in the area and to provide access to other new settlements to the north and east, such as Hanover and Enfield.

Lebanon was one of sixteen towns in western New Hampshire to secede from the state and join the newly formed state of Vermont. The 'Vermont Controversy' began in the 1760s during the settlement of the Connecticut Valley towns. There were few similarities between the older, more aristocratic eastern towns, like Portsmouth and Exeter and the new, smaller frontier towns in the west, mostly in the Connecticut River Valley. The people of the western towns of Cheshire and Grafton counties felt they were not being adequately represented in the legislature, and by 1776 when New Hampshire had declared its independence from Britain, Lebanon and other towns on the east side of the Connecticut were increasingly discontented with the degree of representation they were allowed in the new state assembly.

In 1778 Vermont petitioned the Continental Congress to become a separate state and Lebanon and 15 other towns voted to join the new state. Vermont rejected their petition to be included, fearing that accepting the towns from New Hampshire might harm their chances of being recognized as a sovereign state. The New Hampshire delegation to the Congress had already introduced a protest against the Vermont petition in response to inclusion of the New Hampshire towns. As a result of a vote of the Vermont assembly, the New Hampshire towns were not included as a county or territory in the state. Lebanon remained independent of New Hampshire and Vermont until 1782, when after many delays and conventions with the other Connecticut Valley towns, it again took its place as a town in the state of New Hampshire.

By 1786, the population in Lebanon had reached 843. Various plans were developed to improve transportation routes throughout New Hampshire. A charter was granted for the Fourth New Hampshire Turnpike on 25 November 1800. The turnpike had its northern terminus at West Lebanon. Four, six and eight horse teams carried farm produce to Portsmouth and Boston. The Fourth New Hampshire Turnpike roughly followed what is now Route 4. Lyman's bridge connected the Fourth New Hampshire Turnpike with the White River Turnpike in Vermont.

At the beginning of the nineteenth century, the economy of Lebanon was mainly based on farming. Cattle and horses were raised for market. Trees were used for high quality lumber, and those not fit for lumber were burned for potash. Almost every brook held a temporary sawmill. Flax was grown to produce fiber for clothing and oil from the seeds. Lebanon had many stores at this time and seven or eight taverns, many on the 'River Road'. There were several tanneries and lumber was manufactured largely at a Mr. Payne's mills located at several points on the Mascoma River. Trade was still chiefly with the state of Connecticut. Much of the lumber from this area was floated in rafts down the Connecticut River to Hartford.

Lebanon's population was around 1600 in 1810, and 1,710 in 1820. Many mills were in operation at this time; most of them were located on the Mascoma River. There were six sawmills, several tanneries, a machine shop, an oil mill and a hat factory. The Mechanics Cotton and Woolen Factory, the Lebanon Cotton Factory in East Lebanon and Andrew Post's hat factory were several manufactories in operation on the river.

The principal means of transportation in 1820 was still the Fourth New Hampshire Turnpike. Four, six, and eight horse teams carried the farm produce to market in Boston and Portsmouth, and returned with finished goods for sale. The Connecticut River was still the primary transportation route between Hartford and Lebanon. Large boats were used to float the goods down with the current to market and returned using poles and oars, sometimes assisted by sails.

In 1838, a charter was granted for a railroad through Lebanon, New Hampshire. There was fierce opposition from farmers who felt the railroad would divide their farms, kill their cattle and ruin the market for their stage horses and teams. It became so difficult to obtain a railroad charter from the New Hampshire legislature, that the threat was made to bypass New Hampshire. Eventually, the charter was obtained and the railroad was built along the Mascoma River and opened to Lebanon sometime before 1860.

On 13 May 1887, a fire struck the main manufacturing district of Lebanon. Eighty buildings were destroyed, 40 families were left homeless and 600 people were out of work. Twenty or more business establishments on both sides of the Mascoma River were destroyed. The damages were extensive but the area was gradually rebuilt as the town's manufacturing center.

Summary

The Mascoma River has provided waterpower for many mills and businesses since the settlement of Lebanon in 1763. Lebanon had the advantage of a reliable transportation route for the products of its factories, the Connecticut River, to the markets of Hartford and New York. Therefore, the town prospered as a small commercial center. While the 'Great Fire of 1887' and subsequent development in the nineteenth and twentieth centuries may have destroyed many of these mills and manufactories, some may be present as historical archaeological sites. Many dams still remain on the river, many still in good repair and operation, as a tribute to the Mascoma's continuing importance to the region. Other historic sites, such as farms and commercial establishments may be found along the land transportation routes, such as the 'River Road', or the Fourth New Hampshire Turnpike, and the railroad line.

In the specific study area encompassing Riverdale and Mahan Flats, preliminary historic research suggests that most structures currently under study were built later than 1860. Only one house, in the Riverdale section appears on the 1860 map. Specific, detailed deed research would be required if structural alternatives are pursued (wall, dikes, rip-rapping) to confirm this preliminary finding. Flood-proofing of structures, or house raising, would have to be reviewed if any structures were considered historic by the New Hampshire SHPO. Flood-proofing or house raising would probably have minor effects, on historic properties.

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APPENDIX D

CORRESPONDENCE

United States Department of the Interior

FISH AND WILDLIFE SERVICE
400 RALPH PILL MARKETPLACE
22 BRIDGE STREET
CONCORD, NEW HAMPSHIRE 03301-4901

Mr. Joseph L. Ignazio, Chief
Planning Division
ATTN: Impact Analysis Branch
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254-9149

AUG 2 2 1988

Dear Mr. Ignazio:

This responds to your request, dated August 4, 1988, for information on the presence of Federally listed and proposed endangered or threatened species in connection with your initiation of reconnaissance investigations for development of flood damage reduction measures in flood prone areas in the Kennebec, Androscoggin, and Penobscot River basins in Maine; the Mascoma and Ashuelot River basins in New Hampshire; and the coastal breach at Nauset Beach in Chatham, Massachusetts.

The following endangered and threatened species are found within your proposed project areas and are shown below by state and general location.

Maine

Kennebec River Basin: Bald Eagles (Haliaeetus leucocephalus) nest and overwinter at a number of sites from Augusta south. The threatened Piping Plover (Charadrius melodus) nest and feed on coastal beaches.

Androscoggin River Basin: The headwater reaches have sites with a strong potential for nesting by Peregrine Falcons (Falco peregrinus).

Penobscot River Basin: Bald Eagles nest and overwinter throughout this river basin.

New Hampshire

Mascoma River Basin: No listed species

Ashuelot River Basin: The dwarf wedge mussel (Alasmidonta heterodon), soon to be proposed as an endangered species, is found below the Surrey Dam. Surveys of this basin for additional populations are underway.

Massachusetts

Nauset Beach, Chatham: Piping Plovers are known from this area and have nested on South Beach Island and North Beach. Potential nesting and feeding habitat exists throughout this area.

You may wish to contact Steve Timpano of the Maine Department of Inland Fisheries and Wildlife, 284 State Street, Augusta, Maine, at 207-289-5258; the Massachusetts Natural Heritage Program, 100 Cambridge Street, Boston, Massachusetts, at 617-727-9194; and the New Hampshire Department of Resource and Economic Development, P.O. Box 856, Concord, New Hampshire, at 603-271-3623 for information on state listed species.

This response relates only to endangered species under our jurisdiction. It does not address other legislation or our responsibilities under the Fish and Wildlife Coordination Act.

Lists of Federally designated endangered and threatened species in New Hampshire, Massachusetts, and Maine are inclosed for your information. Thank you for your cooperation and please contact Mr. Roger Hogan of this office at 603-225-1411 if we can be of further assistance.

Sincerely yours,

Gordon E. Beckett

Inclosure

Gordon E. Beckett
Supervisor
New England Area

FEDERALLY LISTED ENDANGERED AND THREATENED SPECIES
IN MAINE

Common Name	Scientific Name	Status	Distribution
FISHES:			
Sturgeon, shortnose*	Acipenser brevirostrum	E	Kennebec River & Atlantic Coastal Waters
REPTILES:			
Turtle, leatherback*	Dermochelys coriacea	E	Oceanic summer resident
Turtle, loggerhead*	Caretta caretta	T	Oceanic summer resident
Turtle, Atlantic ridley*	Lepidochelys kempii	E	Oceanic summer resident
BIRDS:			
Eagle, bald	Haliaeetus leucocephalus	E	Entire state-nesting habitat
Falcon, American peregrine	Falco peregrinus anatum	E	Entire state-reestablishment to former breeding range in progress
Falcon, Arctic peregrine	Falco peregrinus tundrius	E	Entire state migratory-no nesting
Plover, Piping	Charadrius melodus	T	Entire state - nesting habitat
Roseate Tern	Sterna dougallii dougallii	E	Atlantic Coast
MAMMALS:			
Cougar, eastern	Felis concolor couguar	E	Entire state-may be extinct
Whale, blue*	Balaenoptera musculus	E	Oceanic
Whale, finback*	Balaenoptera physalus	E	Oceanic
Whale, humpback*	Megaptera novaeangliae	E	Oceanic
Whale, right*	Eubalaena spp. (all species)	E	Oceanic
Whale, sei*	Balaenoptera borealis	E	Oceanic
Whale, sperm*	Physeter catodon	E	Oceanic
MOLLUSKS:			
NONE			
PLANTS:			
Small Whorled Pogonia	Isotria medeoloides	E	York, Kennebec, Cumberland, Oxford Counties
Lousewort, Furbish's	Pedicularis furbishiae	E	Aroostook County

* Except for sea turtle nesting habitat, principal responsibility for these species is vested with the National Marine Fisheries Service

Rev. 1/25/88

FEDERALLY LISTED ENDANGERED AND THREATENED SPECIES
IN NEW HAMPSHIRE

Common Name	Scientific Name	Status	Distribution
FISHES:			
Sturgeon, shortnose*	Acipenser brevirostrum	E	Atlantic Coastal Waters
REPTILES:			
Turtle, leatherback*	Dermochelys coriacea	E	Oceanic summer resident
Turtle, loggerhead*	Caretta caretta	T	Oceanic summer resident
Turtle, Atlantic ridley*	Lepidochelys kempii	E	Oceanic summer resident
BIRDS:			
Eagle, bald	Haliaeetus leucocephalus	E	Entire state-migratory
Falcon, American peregrine	Falco peregrinus anatum	E	Entire state-reestablishment to former breeding range in progress
Falcon, Arctic peregrine	Falco peregrinus tundrius	E	Entire state migratory-no nesting
Plover, Piping	Charadrius melodus	T	Entire state migratory-nesting uncertain
Roseate Tern	Sterna dougallii dougallii	E	Atlantic Coast
MAMMALS:			
Cougar, eastern	Felis concolor couguar	E	Entire state-may be extinct
Whale, blue*	Balaenoptera musculus	E	Oceanic
Whale, finback*	Balaenoptera physalus	E	Oceanic
Whale, humpback*	Megaptera novaeangliae	E	Oceanic
Whale, right*	Eubalaena spp. (all species)	E	Oceanic
Whale, sei*	Balaenoptera borealis	E	Oceanic
Whale, sperm*	Physeter catodon	E	Oceanic
MOLLUSKS:			
NONE			
PLANTS:			
Jesup's milk-vetch	Astragulus robbinsii var. jesupi	E	Connecticut Rvr. Valley
Robbins cinquefoil	Potentilla robbinsiana	E	Coos County
Small Whorled Pogonia	Isotria medeoloides	E	Belknap, Strafford, Merrimack, Grafton, Carroll, Rockingham, Hillsborough Counties

* Except for sea turtle nesting habitat, principal responsibility for these species is vested with the National Marine Fisheries Service

Rev. 1/25/88

FEDERALLY LISTED ENDANGERED AND THREATENED SPECIES
IN MASSACHUSETTS

Common Name	Scientific Name	Status	Distribution
FISHES:			
Sturgeon, shortnose*	Acipenser brevirostrum	E	Connecticut River & Atlantic Coastal Waters
REPTILES:			
Turtle, green*	Chelonia mydas	T	Oceanic straggler in Southern New England
Turtle, hawksbill*	Eretmochelys imbricata	E	Oceanic straggler in Southern New England
Turtle, leatherback*	Dermochelys coriacea	E	Oceanic summer resident
Turtle, loggerhead*	Caretta caretta	T	Oceanic summer resident
Turtle, Atlantic ridley*	Lepidochelys kempii	E	Oceanic summer resident
Turtle, Plymouth red-bellied	Chrysemys rubriventris bangsi	E	Plymouth & Dukes Counties
BIRDS:			
Eagle, bald	Haliaeetus leucocephalus	E	Entire state
Falcon, American peregrine	Falco peregrinus anatum	E	Entire state-reestablishment to former breeding range in progress
Falcon, Arctic peregrine	Falco peregrinus tundrius	E	Entire state migratory-no nesting
Plover, Piping	Charadrius melodus	T	Entire state - nesting habitat
Roseate Tern	Sterna dougallii dougallii	E	Atlantic Coast
MAMMALS:			
Cougar, eastern	Felis concolor couguar	E	Entire state-may be extinc
Whale, blue*	Balaenoptera musculus	E	Oceanic
Whale, finback*	Balaenoptera physalus	E	Oceanic
Whale, humpback*	Megaptera novaeangliae	E	Oceanic
Whale, right*	Eubalaena spp. (all species)	E	Oceanic
Whale, sei*	Balaenoptera borealis	E	Oceanic
Whale, sperm*	Physeter catodon	E	Oceanic
MOLLUSKS: NONE			
PLANTS:			
Small Whorled Pogonia	Isotria medeoloides	E	Hampshire, Essex Hampden, Worcester Middlesex Counties
Gerardia, Sandplain	Agalinus acuta	**PE	Barnstable County

* Except for sea turtle nesting habitat, principal responsiblity for these species is vested with the National Marine Fisheries Service

** Potentially endangered

Rev. 1/25/88

United States Department of the Interior

FISH AND WILDLIFE SERVICE
400 RALPH PILL MARKETPLACE
22 BRIDGE STREET
CONCORD, NEW HAMPSHIRE 03301-4901

Mr. Joseph Ignazio, Chief
Planning Division
New England Division
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254

AUG 3 1 1988

Dear Mr. Ignazio:

This planning aid letter is intended to provide a preliminary assessment of potential fish and wildlife impacts from several alternatives evaluated by the New England Division for the flood protection reconnaissance study of the Mascoma River, Grafton County, New Hampshire. It has been prepared under the authority of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.).

The reconnaissance investigation focuses on three primary flood damage areas along the Mascoma River. Two of the sites, Mahan Flats and Riverdale, are in the City of Lebanon upstream of the Cummings Tannery Dam site. The third site is approximately 10 miles upstream near West Canaan, adjacent to the intersection of Route 4 and Goose Pond Road.

PROPOSED FLOOD CONTROL MEASURES

Two types of flood control measures are being examined for the Mascoma River reconnaissance study: structural measures to reduce flooding and non-structural measures to reduce or mitigate flood damages. Among the structural alternatives that would reduce flooding prior to reaching critical damage areas are reservoirs, diversions, and land treatments. The only one of these measures considered feasible for this study is the regulation of existing upstream reservoirs to provide additional flood storage.

Structural measures that would reduce flooding at the critical areas include levees, floodwalls, and channel modifications. One or more of these measures are being considered for all three of the Mascoma River flood damage areas.

Non-structural flood control measures such as floodproofing buildings and relocation of flood-prone structures (depending on the site where the structures are relocated to) usually do not cause significant adverse impacts to fish and wildlife resources. Non-structural flood control measures are preferred by the Fish and Wildlife Service due to their low level intensity of adverse impacts.

HABITAT CHARACTERISTICS OF THE STUDY AREAS

The Mascoma River is a tributary of the Connecticut River that drains a basin of approximately 194 square miles in west-central New Hampshire. The Mascoma River Basin contains numerous small ponds and lakes, including the 1155-acre

Mascoma Lake which lies approximately 5 miles upstream of Lebanon. The watershed is primarily forested and consists of rolling hills ranging in elevation from 3200 feet msl in the headwaters, to 340 feet at the confluence with the Connecticut River. Elevations in the project area range from 800 feet at West Canaan to 580 feet at Mahan Flats in Lebanon.

Mahan Flats

The Mahan Flats area lies to the south of the Mascoma River in the City of Lebanon. According to the FEMA National Flood Insurance Program maps, the area within the 100-year floodplain extends along the river for approximately 4350 feet. It is bounded to the south by the Boston and Maine railroad tracks, to the east by the old Spencer Street bridge crossing, and to the west by Hanover Street near the Cummings Tannery Dam site. The floodplain boundary on the north side of the river is formed by the Interstate 89 fill.

The Mahan Flats study area consists of four general covertypes: deciduous riparian vegetation; grasslands; emergent wetlands; and urbanized areas.

The deciduous riparian covertype is found immediately adjacent to the Mascoma River. A dense band of riparian vegetation, ranging from 10 to 100 feet wide (average width approximately 50 feet), occurs along both sides of the river for almost the entire length of this reach. The variety of tree, shrub, and herbaceous species that comprise the riparian zone here form a multi-story canopy which offers excellent habitat conditions for avian and terrestrial wildlife. Overstory species include box elder, American elm, willow, red maple, and white birch. The well developed understory contains red osier and silky dogwood, european buckthorn, elderberry, ironwood, and honeysuckle. Jewel-weed, ground ivy, galium, buttercup, wood sorrel, grape, raspberry, willow herb, and several grasses make up the herbaceous ground cover.

The open grassland covertype lies in a narrow band that separates the wooded riparian zone from the urban cover type. This area appears to have been previously disturbed and although several species of upland grasses are prevalent now, the area is being invaded by a variety of pioneering species. Among these are sumac, quaking and big-tooth aspen, balsam poplar, japanese knotweed, and raspberry.

Emergent wetlands with cattail and tussock sedge are found in several localized sites along the river banks. They occur primarily in backwater areas along the northern bank where fine sediments have been deposited. Although they represent a small percentage of the study area, these areas have high value to wildlife. We have observed use by wading and shorebirds on several occasions.

The urbanized areas are comprised of playfields, a recreation center, residential homes, roads, commercial businesses, and small manufacturers. They offer little habitat value for wildlife except for small mammal and bird species that may use residential yards and ornamental plantings.

Riverdale

The 100-year floodplain in the Riverdale area lies between the Mascoma River to the south and Interstate 89 to the north. It extends from the railroad tracks just upstream of the Bank Street bridge crossing on the east, to a point approximately 2700 feet downstream where a river bend meets the Interstate fill. The area of concern for this reconnaissance study consists of the residential property along Riverdale Parkway and the vegetated corridor between the residential area and the Mascoma River.

The Riverdale study area consists of three different covertypes: deciduous riparian vegetation, wooded grasslands, and residential areas.

Deciduous riparian vegetation is found throughout the narrow corridor between the Mascoma River and the residences along Riverdale Parkway. Plant species in this riparian zone, particularly the overstory trees, are similar to those found at Mahan Flats. The primary difference is that the understory at Riverdale has been altered by human activities associated with the adjacent residential development (e.g.understory brush clearing), and as a result is much more open. Ground cover is primarily vine species such as Virginia creeper and grape. Day lilies and other escaped ornamentals are also present. Although only 10 to 15 feet wide, this riparian corridor provides substantial shade and overhanging bank cover that benefits terrestrial, arboreal, and aquatic organisms.

The wooded grassland covertype encompasses a large area extending approximately 0.25 miles west from the end of Riverdale Parkway, however, only a small area in the northwest corner of the Riverdale study site lies within this covertype. Wooded grasslands here represent former pasture land that is undergoing old field succession. There is a patchy overstory of pioneering trees and shrubs such as sumac, poplar, and aspen. The dense grassy understory is being colonized by honeysuckle, barberry, raspberry, thistle and other invaders. The mosaic of open grassy patches combined with clumps of shrubs and trees offers excellent habitat for species such as cottontail, pheasant, red fox, passerine birds, and white-tailed deer.

The residential covertype consists of houses and manicured lawns. This covertype provides limited habitat for wildlife such as the gray squirrel, house sparrow, and other urban-oriented species.

Route 4 Area

The study area adjacent to Route 4 encompass a variety of covertypes including palustrine wetlands, riparian vegetation, upland pastures, and developed areas. The flood-prone study area lies to the north of Route 4 and to the west of the Mascoma River. This area is primarily grazed pasture with grasses, forbs, and patches of bare ground. There is a small stand of poplar and birch trees adjacent to the flood prone buildings. Immediately to the northwest within the pasture, there is a small palustrine wetland, approximately 0.25 acres in size. The wetland contains yellow pond lilies and is partially bordered by spirea. A dense algal mat, indicative of eutrophic conditions, was present during our July 7, site inspection. The single small feeder spring was almost dry. Judging by the presence of floodplain overflow channels, it appears that the wetland is recharged by seasonal flooding of the Mascoma River.

Vegetation along the river to the north of Route 4 consists primarily of mature red maple trees that provide shade, overhanging cover, and bank stability. Adjacent to the Route 4 bridge and extending upstream is a dense, 15 to 20-foot-wide band of shrub-scrub palustrine wetlands. The primary species here are red-osier dogwood, gray birch, spirea, and red maple. On the south side of Route 4, landward of the palustrine wetlands, there is a narrow band of disturbed ground that has been used by offroad vehicles. Abutting this disturbed area is a mixed stand of coniferous/deciduous trees; including white pine, American elm, choke cherry, red oak, and ironwood. Ground cover includes cinnamon fern, poison ivy, and Virginia creeper.

FISH AND WILDLIFE RESOURCES

The edge effect created by the juxtaposition of riparian vegetation, grasslands, and flowing water at all of the sites results in excellent habitat values for birds and small mammals. Small snags that provide habitat for cavity nesting wildlife are found in the riparian zone at Mahan Flats and Riverdale. Among the birds we observed during our site inspections were: downy woodpecker, black-capped chickadee, yellow warbler, common yellowthroat, white-breasted nuthatch, wood thrush, American robin, red-winged blackbird, green-backed heron, great blue heron and spotted sandpiper. Other birds that could be expected to use the area include: belted kingfisher, eastern kingbird, tree swallow, red-tailed hawk, kestrel, wood duck and mergansers.

Wildlife sign observed at the sites included raccoon, beaver, and other small mammal tracks in the mud along the river. Common wildlife species in addition to beaver and raccoon that could be expected to use the project sites would include: shrews, voles and mice, gray squirrel, flying squirrel, muskrat, snowshoe hare, New England cottontail, porcupine, striped skunk, mink, long- and short-tailed weasel, red fox, and white-tailed deer.

Aquatic habitat in the study areas is varied, encompassing low velocity pool habitat at the lower end of Mahan Flats, pool-riffle habitat with gravel/cobble substrate at the upper Mahan Flats and Riverdale sites, and low gradient areas with sandy substrate in the Route 4 vicinity. Although the river banks have been armored with riprap in the Lebanon areas, aquatic habitat conditions are now good due to the subsequent deposition of gravel and large woody debris, as well as the growth of dense streamside vegetation. Stream banks in the Route 4 study areas are primarily sandy with shrubby vegetative cover. North of Route 4, shading is provided by mature red maple trees.

Fish species that can be expected to occur in the Mascoma River would include brook, brown, and rainbow trout; all of which are stocked annually by the New Hampshire Department of Fish and Game. Due to the presence of Mascoma Lake, a variety of other species can be found in the Mascoma River including: smallmouth bass, rock bass, yellow perch, brown bullhead, common sucker, eastern and common shiners, creek chub, fall fish, eastern black- and long-nosed dace, eastern johnny darter, and slimy sculpin.

All of the sites offer easy fisherperson access. Fishing pressure is presumed to be high based on the large numbers of trout stocked annually. For example, in 1987, a total of 9248 trout (6940 brook, 1608 brown, and 700 rainbow) were planted in the Lebanon-Enfield area by the New Hampshire Fish and Game Department.

Fishery management in the Mascoma River will eventually be affected by the Connecticut River Atlantic Salmon Restoration Program. This is a cooperative state-federal effort, begun in 1967, to restore and maintain Atlantic salmon in the Connecticut River Basin at a level sufficient to provide both natural spawning populations and a sport fishery. The Mascoma River is not one of the initial ten high priority rivers designated for restoration (deferred status). However, once the long-term program goal of full watershed utilization is realized, fish passage will likely be required at the Mascoma River dams to allow the reintroduction of anadromous species into the basin.

POTENTIAL PROJECT IMPACTS

Regulation of Existing Reservoirs

There are a number of ponds and reservoirs within the Mascoma River basin that could be regulated to provide additional storage for seasonal high flows. Reservoirs in the Mascoma Lakes system operated by the New Hampshire Water Resources Board are shown in the table below:

Reservoir	Surface Area (acres)	Storage Capacity (acre-feet)	Surface Elevation (U.S.G.S.)
Grafton Pond	321	3,168	1241
Crystal Lake	441	2,500	625
Goose Pond	668	12,300	845
Mascoma Lake	1,155	10,300	751

The New England Division (NED) planning staff has indicated that the only one of these reservoirs being considered to provide additional flood storage is Mascoma Lake. Mascoma Lake is formed by the 18-foot-high wood crib Mascoma Dam. The present uses of Mascoma Dam are water storage, downstream flow regulation, and recreation. There is currently no hydroelectric generating capacity at the dam, although hydropower potential has been investigated by the New Hampshire Water Resources Board.

The current management regime for Mascoma Lake involves keeping the pool full to elevation 751 during the summer months for recreation, then drawing the reservoir down four feet starting in October to provide winter storage capacity. It is our understanding that additional reservoir drafting under consideration for this reconnaissance study would be limited to approximately six to twelve inches.

Drafting of Mascoma Lake to provide additional flood storage capacity could cause a number of adverse impacts to fish and wildlife resources. The release of flows above ambient levels could affect downstream fish resources and aquatic habitat both during the releases and upon return to ambient flows. Depending on the rate of drawdown, ramping rates (rate of river stage change) may need to be established to prevent scouring of the streambed and aquatic organisms when flow releases are increased. Down-ramping rates may be needed to prevent fish stranding on gravel bars and side channels upon returning to normal flows.

Additional information is needed regarding the rate that flow releases would be made from the reservoir before we can fully evaluate the effect of reservoir drafting on downstream fishery resources. However, provided that releases are made gradually over a long period of time, downstream fishery impacts should not be significant.

Water temperature and dissolved oxygen levels could be adversely affected by reservoir drawdown if releases were made during the summer months when the reservoir exhibits thermal stratification. However, we expect that the reservoir would be adequately mixed by late fall when drawdown would occur so that downstream temperature and oxygen impacts should not be a significant factor.

Increasing the annual drawdown from 4 feet to 5 feet would reduce the surface area of the reservoir by approximately nine acres. This in turn would cause an undetermined area of perimeter lakebed to be exposed to the elements during the winter months. Water quality could be affected by increased sedimentation from the erosion of exposed shoreline by the action of waves, precipitation, and ice. Additional investigations to determine both the total area of exposed shoreline and its geologic characteristics will be necessary to evaluate the potential for erosion-related water quality impacts associated with additional winter drawdown.

Reservoir drawdown can impact wildlife in the impoundment and in downstream reaches. Additional exposure of the lake margins can reduce food and cover for insects, fish, and other aquatic organisms by eliminating algae and vascular aquatic plants. Sessile or slow moving organisms found in the littoral zone, such as freshwater mussels, would likely perish from exposure or predation. Depending on the magnitude of flow releases, bank nesting birds and mammals in downstream river reaches could be flooded.

The primary adverse effect of additional reservoir drafting would be to fish, wildlife, and plant life in the exposed littoral zone. Based on reservoir data provided by the Water Resources Division of the New Hampshire Department of Environmental Services, it appears that the surface area of the reservoir would be reduced by approximately nine acres if the lake is drawn down an additional 12 inches (i.e. five foot drawdown instead of four). Further study is needed to determine the area of exposed shallow water habitat associated with this reduction of surface area. Also needed are site specific investigations of the temporal and spatial distribution of plant and animal life residing in the exposed area, as well as an analysis of their ability to survive annual dewatering.

In considering operational changes to Mascoma Lake to provide additional flood storage, we believe it would be desirable to modify the reservoir rule curves (spring fill-up and fall drawdown schedules) so that the water levels in the reservoir more closely emulate the natural rhythmical pattern of unregulated lakes in the northeast. This could be accomplished by surcharging the reservoir during the spring runoff period, and allowing a more gradual, less severe drawdown that mimics the natural hydrology. Although reservoir surcharging may require the acquisition of additional flowage easements around the reservoir, it would be beneficial to fish and wildlife resources in and downstream of the lake. We recommend that this option be investigated during the project feasibility investigations.

Levees and Flood Walls

The primary impacts of levee and floodwall construction would be the direct physical loss of habitat from construction of the structures and construction-related impacts to habitat and water quality. Construction of floodwalls and/or levees along the Mascoma River at any of the three study sites would eliminate shallow-water rearing habitat, overhanging bank cover, and high quality riparian habitat. Impacts would extend beyond the actual footprint of the levee or floodwall if they prevent seasonal high flows from recharging adjacent wetland or riparian areas. Due to the high habitat value of these areas and the difficulty in developing successful mitigation, we would recommend against the construction of levees and floodwalls within these productive shallow water habitats, wetlands, or streamside riparian buffers.

In addition to direct habitat losses from construction of the flood control structures, wildlife utilizing adjacent habitats would be temporarily displaced during disruptive construction activities. Depending on the season and length of the construction period, temporary displacement may lead to direct mortality due to nest abandonment or dispersal-related losses (predation, competition, road kill, etc.). This disturbance factor would apply to all structural flood control measures. Although disturbance cannot be eliminated, mortality associated with nest failure can be reduced by scheduling all construction activities for the late summer and fall months.

The ordinarily severe impacts from either floodwall or levee construction can be substantially lessened if the structure is built well back from the river bank and riparian buffer zone. Also, the use of floodwalls would have relatively less impact than levees due to their reduced physical coverage. At the Mahan Flats site, it may be possible to construct a combination of floodwalls and levees in residential yards and grassland areas without causing unacceptable impacts to fish and wildlife habitat. We will need to review additional information on the actual siting of structures, physical extent of coverage, structure design, and construction techniques before we can fully evaluate the impact of this alternative. Before mitigation measures can be developed, more detailed evaluations of the habitat value of affected areas for target species would have to be completed.

At the Route 4 study site, levees or flood walls could be constructed well back from the river within the pasture areas to avoid impacts to riparian and aquatic habitat. Care will be necessary on the south side of Route 4 to insure the levee or floodwall does not encroach on wetlands and is contained within the areas already impacted by human use.

Levees would encroach excessively on the streamside environment at the Riverdale area due to the close proximity of residential housing to the river. The use of flood walls instead of levees would reduce impacts, however,the loss of streamside cover is inevitable if either levees or walls are constructed in this area. We therefore recommend that only nonstructural alternatives such as floodproofing or building relocation be utilized at this site.

Channel Modification

Modification of the river channel to increase flood storage capacity by deepening and/or widening could cause serious adverse impacts to fish and wildlife resources. Direct impacts from channel modification would include both direct mortality of fish and small terrestrial wildlife and permanent habitat loss. Channel widening could have greater impacts than channel deepening since the adjacent riparian vegetation and riverine wetlands would be eliminated.

Both dredging and channel widening would destroy aquatic organisms, including fish eggs, larvae, and juveniles residing in the substrate at the time of disturbance. Habitat suitability for most aquatic species would decrease with the loss of important habitat components such as instream object cover, large organic debris, overhanging bank cover, and shading from overhead trees. Shifts in both fish and invertebrate communities can be expected with changes in channel morphology and habitat structure. As with the other structural flood control measures, succession in adjacent wetlands and riparian woodlands may also be affected with the elimination of annual flooding and nutrient deposition that maintain those habitat types in their current productive form.

Adverse effects to resources downstream of the project area could also be expected. Water quality would be degraded as a result of elevated levels of fine sediments, BOD, and possibly contaminants resulting from the disturbance of riverbed sediments during instream construction activities. Increasing the channel capacity at certain localized areas will eliminate the natural flood desychronization/storage, sediment trapping, and velocity damping functions performed by the existing vegetated floodplains. While flood damages may be reduced at the specific study sites, the accelerated current velocity and increased suspended sediment load may impact fish and wildlife as a result of streambank erosion and sediment deposition.

Because of the magnitude of both onsite and downstream impacts to fish and wildlife resources, we do not recommend that any form of channel modification be pursued along the Mascoma River.

Nonstructural Measures

The use of nonstructural measures to prevent flood damage would, for the most part, not impact the fish and wildlife resources of the Mascoma River. The only possibility of habitat degradation from nonstructural measures would be if houses or other structures were relocated to areas currently occupied by wetlands or other wildlife habitat areas that are currently undeveloped.

SUMMARY

All of the structural alternatives for flood control in the Mascoma River study area have the potential to cause significant adverse impacts to important fish and wildlife resources. We recommend that nonstructural measures be used where possible to accomplish flood control objectives on the Mascoma River because they offer a solution that is essentially free of impacts to natural environmental features.

Additional drawdown of Mascoma Lake may be an acceptable flood control solution if the drawdown is limited to 12 inches or less; however, site specific data on littoral zone biota and the extent of lake bottom exposure are necessary to fully evaluate the impacts of increased reservoir drawdown. In considering modifications to lake level management, it would be desirable if water levels in Mascoma Lake more closely emulate the natural hydrologic pattern of unregulated lakes in the region.

We would not object to the limited use of levees or floodwalls at the Mahan Flats, Riverdale, or Route 4 areas if the structures are: 1) set back considerably from the riverbanks; 2) designed to avoid wetlands; 3) leave the full width of vegetated streamside buffer areas intact; and 4) constructed using techniques that would prevent water quality impacts. It appears unlikely that these criteria can be fully met at Riverdale or for portions of Mahan Flats because of inadequate setback space. Our review of more detailed site specific local protection plans will be necessary before we can determine the extent that these criteria can be successfully met at all three sites.

We do not recommend that channel modification be pursued further as a flood control option at any of the sites due to unacceptable impacts to fish and wildlife resources.

Thank you for the opportunity to provide these planning aid comments. If you have any questions regarding this letter, please contact Michael Tehan of my staff at (603) 225-1411 or FTS 834-4411.

Sincerely yours,

Gordon E. Beckett

Gordon E. Beckett
Supervisor
New England Area

CC: RO/FWE Reading File
NH F&G, Bill Ingham
Betsy Higgins, EPA
FWE: MTehan:8-31-88:834-4411

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION I
J.F. KENNEDY FEDERAL BUILDING, BOSTON, MASSACHUSETTS 02203-2211

October 24, 1988

Mr. Joesph L. Ignazio, Chief
Planning Division
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, MA 02254-9149

Dear Mr. Ignazio:

Thank you for the opportunity to comment on your reconnaissance study to examine flood damage reduction measures for flood prone areas of the Mascoma River in Lebanon, New Hampshire. While EPA has not seen the site and does not have a document to review, Sue Brown of your staff has provided us with information about the options you are considering.

We have been informed that structural changes are no longer being considered for this river because of the cost ratio for these options. The three structural alternatives originally under consideration were widening the channel, constructing dikes and walls and diverting the water into a new channel. All of these options would have caused major impacts to the aquatic environment by altering the riparian habitat. Riverine wetlands would have been filled while other wetlands would have been altered by disrupting the floodplain hydrology. Removing the forested buffer zone along the river would have destroyed the wildlife cover and restricted animal movement patterns. It would have also removed the shade trees along the bank which help protect the cold water fisheries in the river. Thus, for environmental as well as economic reasons, EPA recommends against these structural choices.

We are encouraged, however, by the non-structural investigations of your study. Floodproofing structures, raising structures, and flood warnings and evacuation all have a minimal impact on the aquatic environment compared to the structural options discussed above. EPA, therefore, prefers the non-structural methods.

Please contact Mark Kern at 565-4426 for further coordination on this project.

Sincerely,

Douglas A. Thompson, Chief
Wetlands Protection Section

cc: M. Tehan, FWS, Concord, NH
K. Kettenring, NH Wetlands Board
R. Manfredonia, EPA, WQB-2103
B. Higgins, EPA, RGR-2203

State of New Hampshire
Fish and Game Department

2 Hazen Drive, Concord, NH 03301
(603) 271-3421

Donald A. Normandeau, Ph.D.
Executive Director

September 23, 1988

Joseph Ignazio, Chief
Planning Division
New England Division
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham MA 02254

Dear Mr. Ignazio:

The following are the Fish and Game Department's preliminary comments regarding the proposals by your agency to control flooding in the Mascoma River watershed. The department is providing comments pursuant to the Fish and Wildlife Coordination Act (48 Stat. 401 as amended; 16 U.S.C. 661 et seq.) and NH RSA 206:9 and 206:01.

The study areas in question are the Mahan Flats and Riverdale area along the Mascoma River in downtown Lebanon and along Crystal Lake Brook in West Canaan. As of the date of this letter it is understood by this department that non-structural flood control measures such as flood proofing buildings and relocating flood-prone structures is the only viable alternative that is being considered for further investigation by your agency. Non-structural measures are preferred by this agency because they do not have the potential to adversely impact fish and wildlife habitats. Consequently, this department does object to the imposition of the non-structural alternative to prevent flood damage. However, the department will provide final comments and recommended fish and wildlife mitigation and compensation when a formal plan for flood protection is provided to this department.

If you have any questions please contact Fish and Wildlife Ecologist, William Ingham, Jr. at (603) 271-2501.

Sincerely,

Donald A. Normandeau

Donald A. Normandeau, Ph.D.
Executive Director

DAN/WCI
cc: William Ingham, Jr.
Gordon Beckett

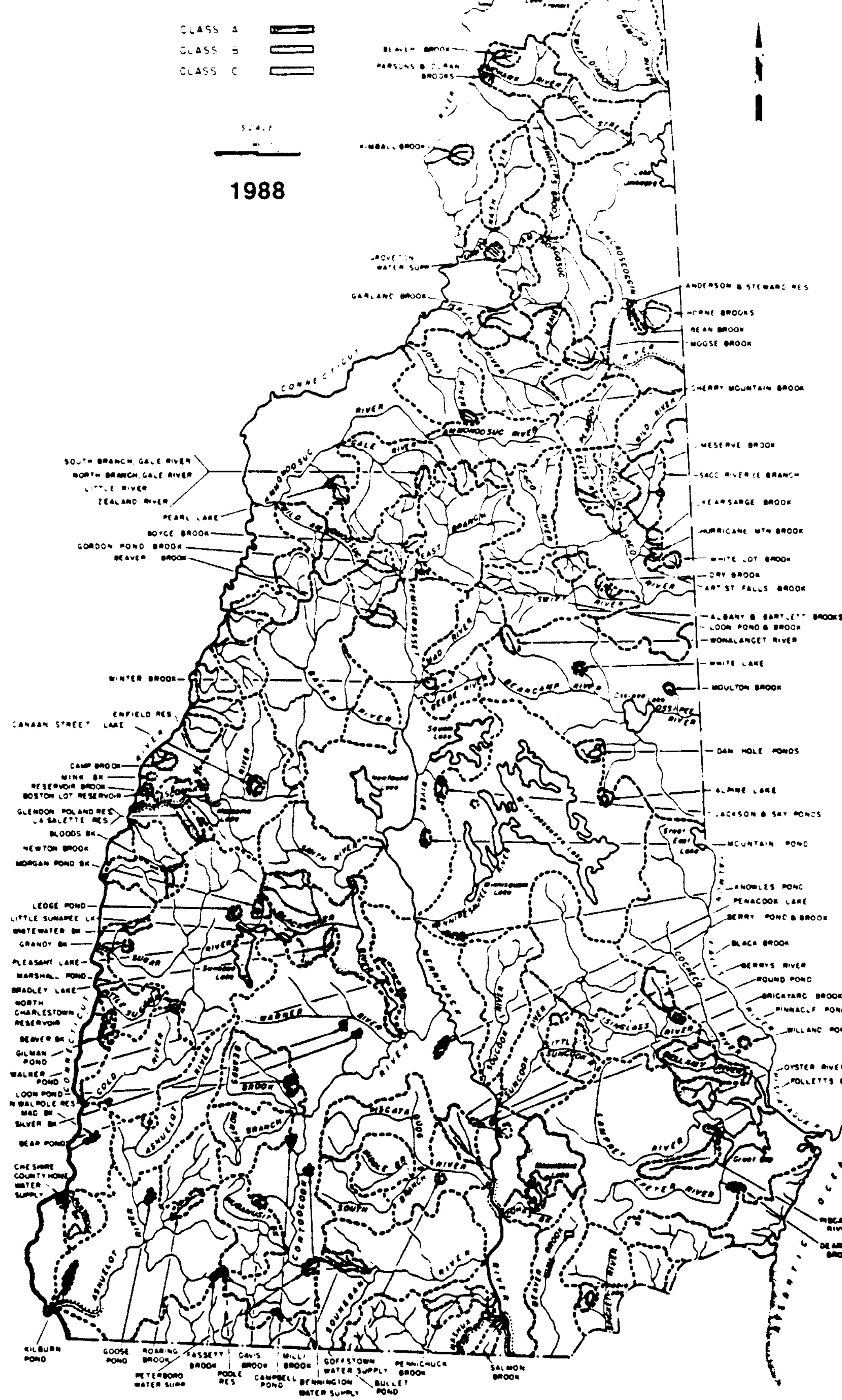
ATTACHMENT 1

LEGISLATIVE CLASSIFICATION OF SURFACE WATERS

NEW HAMPSHIRE DEPARTMENT OF ENVIRONMENTAL SERVICES

WATER SUPPLY AND POLLUTION CONTROL DIVISION

1988



MASCOMA RIVER SURVEY - 28-29 JULY 1981

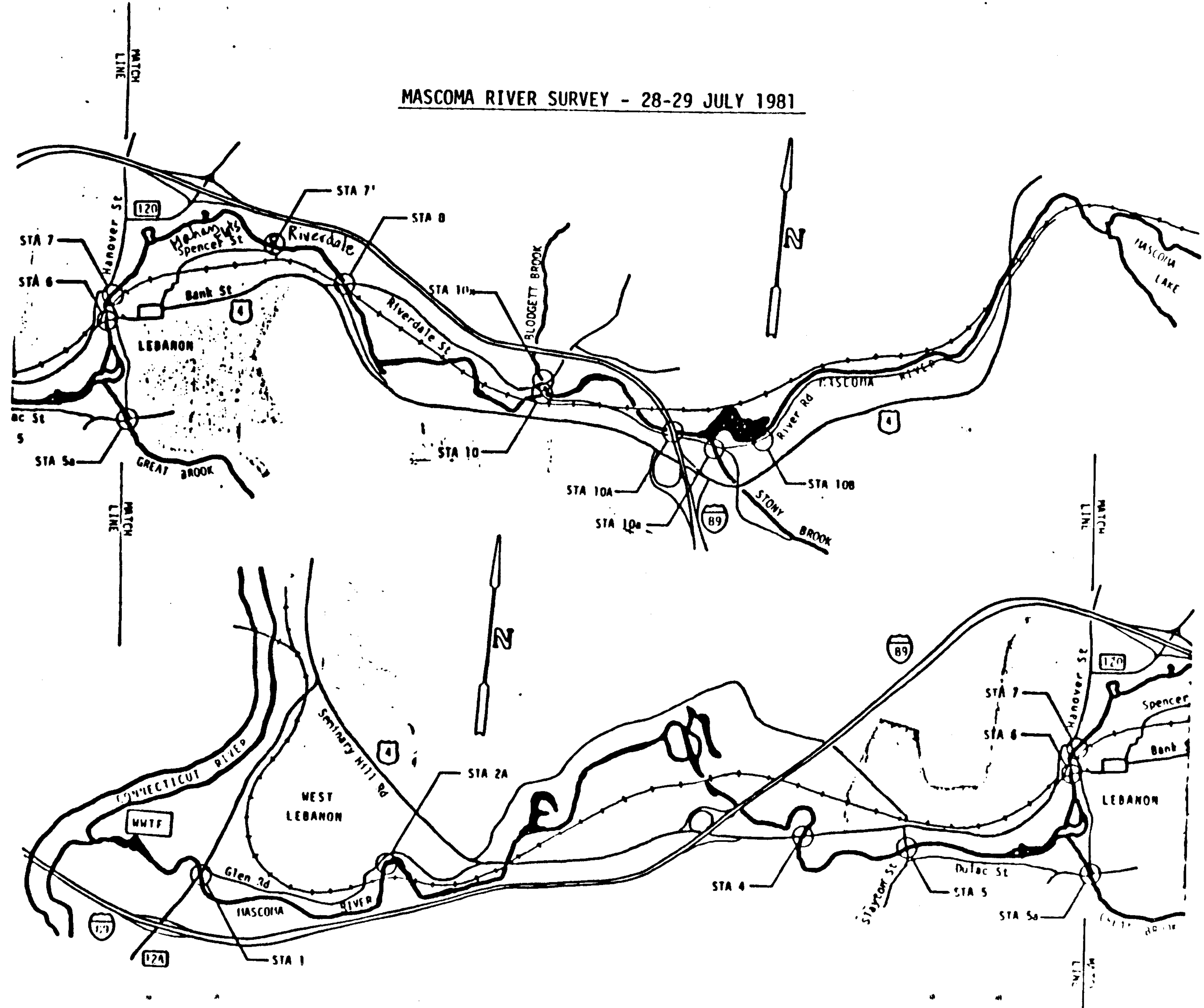


Table I - Results of Field Measurements

MASCOMA RIVER SURVEY - 28-29 July 1981

Station #	Run #1 1000-1145			Run #2 1400-1430			Run #3 1800-1900			Run #4 0830-0930		
	Cond uMHO's	Temp °C	D.O. % Sat.	Cond uMHO's	Temp °C	D.O. % Sat.	Cond uMHO's	Temp °C	D.O. % Sat.	Cond uMHO's	Temp °C	.D.O. % Sat.
1-Msc	68	20.5	99	78	23.0	96	70	22.0	95	450	19.0	94
2A-Msc	65	-	-	70	23.0	100	68	22.0	95	400	-	-
4-Msc	60	20.5	101	-	-	-	-	-	-	-	-	-
5-Msc	60	20.5	99	65	23.0	101	60	22.0	93	400	19.0	94
5a-Grt	174	20.5	104	180	21.0	109	-	-	-	-	-	-
6-Msc	55	20.5	99	-	-	-	-	-	-	-	-	-
7-Msc	55	20.5	101	60	23.0	106	60	23.0	93	390	19.0	89
7'-Msc	50	20.5	99	-	-	-	-	-	-	-	-	-
8-Msc	52	20.5	99	52	23.5	102	50	22.5	94	310	19.0	94
10x-Bgt	210	22.0	101	-	-	-	-	-	-	-	-	-
10-Msc	50	22.5	99	-	-	-	-	-	-	-	-	-
10a-Sto	300	18.0	98	-	-	-	300	22.0	95	315	-	-
10A-Msc	-	-	-	-	-	-	50	-	-	-	-	-
10B-Msc	-	-	-	-	-	-	50	22.0	95	-	-	-

Table II - Results of Bacteria Tests (Counts/100ml)

MASCOMA RIVER SURVEY - 28-29 July 1981

Station #	Run #1 1000-1145			Run #2 1400-1430			Run #3 1800-1900			Run #4 0830-0930		
	Total	Fecal	Strep	Total	Fecal	Strep	Total	Fecal	Strep	Total	Fecal	Strep
1-Msc	4,600	4,600	4,300	930	230	4,300	2,400	430	11,000	110,000	4,300	24,000
2A-Msc	4,600	930	930	2,400	230	2,100	4,600	930	9,300	46,000	2,300	24,000
4-Msc	≥24,000	1,500	-	-	-	-	-	-	-	-	-	-
5-Msc	11,000	4,600	750	11,000	2,400	430	2,100	430	1,500	≥24,000	≥24,000	11,000
5a-Grt	930	<30	390	4,300	90	230	-	-	-	-	-	-
6-Msc	2,400*	930*	930*	-	-	-	-	-	-	-	-	-
7-Msc	11,000	230	4,600	9,300	230	430	2,400	930	1,500	≥24,000	2,400	≥24,000
7'-Msc	90	40	4,600	-	-	-	-	-	-	-	-	-
8-Msc	930	<30	2,400	2,400	40	1,200	430	40	2,100	1,500	430	24,000
10x-Bgt	2,300	230	1,500	-	-	-	-	-	-	-	-	-
10-Msc	430	<30	1,500	-	-	-	-	-	-	-	-	-
10a-Sto	70	<30	2,300	-	-	-	930	<30	430	-	-	-
10A-Msc	-	-	-	-	-	-	390	<30	≥24,000	4,600	40	9,300
10B-Msc	-	-	-	-	-	-	2,400	40	860	-	-	-

* data questionable

Table III - Results of Laboratory Tests

MASCOMA RIVER SURVEY - 28-29 July 1981

Parameter (mg/l)	Station 8-Msc		Station 5-Msc		Station 1-Msc	
	1000	1800	1000	1800	1000	0830
Chloro "A"	3.18	4.18	3.88	3.54	2.44	4.26
TKN	0.50	0.38	0.42	0.37	0.35	0.44
NH_3	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
NO_2+NO_3	<0.05	0.07	<0.05	0.21	<0.05	0.08
Ortho P	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Total P						
Cd	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Ca	6.0	6.0	7.5	6.5	8.0	8.5
Cr	<0.01	<0.01	0.01	0.01	0.01	0.01
Cu	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Fe	0.2	0.2	0.3	0.3	0.4	1.0
Pb	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Mg	0.94	0.88	1.02	0.96	1.12	1.31
Mn	0.16	0.03	0.03	0.05	0.04	0.10
Ni	<0.1	0.1	<0.1	0.1	<0.1	<0.1
K	0.7	0.7	0.8	0.8	0.9	1.1
Na	5	5	6	5	6	7
Sn	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Zn	0.01	0.01	0.01	0.13	0.02	0.02
Alkalinity	11	10	12	11	14	14
Chloride	6	7	8	8	10	12
pH	7.1	6.9	7.1	7.1	7.2	7.1
SO_4	7.5	9.3	8.7	9.0	9.2	7.3

DESCRIPTIONS OF SAMPLING STATIONS

LOWER MASCOMA RIVER

1-Msc	Bridge, South Main Street, Rte 12A, West Lebanon, NH
2A-Msc	Sluiceway, Breached dam, Glen Rd, Lebanon, NH (Bank station)
4-Msc	Bridge, Mechanic St, Rte US 4, Lebanon, NH
5-Msc	Bridge, Slayton St, off Rte US 4, Lebanon, NH
5a-Grt	Great Brook, Bridge, Spring St, Lebanon, NH
6-Msc	Bridge, Mascoma St, downtown Lebanon, NH
7-Msc	Bridge, Hanover St, downtown Lebanon, NH
7'-Msc	Bridge, end of Spencer St, Lebanon, NH
8-Msc	Bridge, Bank Street Extension, Lebanon, NH
10x-Bgt	Bridge culvert, Blodgett Brook, Hardy Hill Rd, Lebanon, NH
10-Msc	Bridge, Riverdale Rd, Lebanon, NH
10a-Sto	Stony Brook, Bridge, Riverside Dr, off Rte US 4, Lebanon, NH
10A-Msc	Riverbank, Riverside Dr, under I-89 overpass, Lebanon, NH
10B-Msc	Riverbank, River Rd (dirt), across from small house, near intersection with Riverside Dr, Lebanon, NH

ATTACHMENT 2

NEW HAMPSHIRE
NATURAL HERITAGE
INVENTORY

Joseph L. Ignazio
Chief, Planning Div.
Dept. of the Army, NE Div.
Corps of Engineers
424 Trapelo Road
Waltham, MA 02254

22 November 1988

RE: Environmental review of the Mascoma River basin.

Dear Mr. Ignazio:

Thank you for consulting the New Hampshire Natural Heritage Inventory regarding the presence of rare plants, animals and exemplary natural communities within the Mascoma River basin study area indicated on your maps.

Enclosed is a list of the "elements" (rare plants, animals and natural communities) known from within the boundaries of the study area. The lists are categorized by town and by County (Grafton and Sullivan). Also enclosed is an explanation of the ranking system used by the Heritage Inventory and a key to the state and federal status.

Please note that this information on environmental elements is not the result of comprehensive field surveys. For this reason, the New Hampshire Natural Heritage Inventory cannot provide a definitive statement on the presence, absence, or status of species or natural communities in the area under consideration. It should also be noted that more data on this area may become available in the future as the inventory expands with ongoing fieldwork and research.

For a more thorough evaluation, it is recommended that a field survey be conducted in the area under consideration.

Sincerely,

Edie E. Hentcy

Ms. Edie E. Hentcy
Data Manager/Biologist

Enclosure

cc: Ed Spencer - The Nature Conservancy -NH

Department of Resources and Economic Development
PO Box 856 CONCORD N.H. 03302-0856

603-271-3623

Scientific Name	Common Name	SRank	GRank	Federal	State	Last Observed
ACER NIGRUM	BLACK MAPLE	S2SU	G5Q		ST	1980-03
BROMUS KALMII	KALM'S BROME-GRASS	SH	G5		SE	1876-07-05
CAMPTOSORUS RHIZOPHYLLUS	WALKING-FERN SPLEENWORT	S1	G5		SE	1876
CAREX CRISTATELLA	SMALL CRESTED SEDGE	S2	G5			1962-06-29
CELTIS OCCIDENTALIS	HACKBERRY	S2	G5		ST	1956-06-27
CONVOLVULUS SPITHAMAEUS	LOW BINDWEED	S2	G4G5		ST	1891-06-02
CORYDALIS AUREA	GOLDEN CORYDALIS	SUSX	G5			NO
CYNOGLOSSUM BOREALE	HOUND'S-TONGUE	S1SU	G3G4Q		SE	1882-06-22
CYPRIPEDIUM ARIETINUM	RAM'S-HEAD LADY'S-SLIPPER	S1	G3	3C	SE	1887-06-02
CYPRIPEDIUM PUBESCENS	LARGE YELLOW LADY'S-SLIPPER	S2	G5		ST	NO
EQUISETUM PRATENSE	MEADOW HORSETAIL	S2	G5		ST	1920-06-12
EQUISETUM VARIEGATUM	VARIEGATED HORSETAIL	S2	G5			1980-08-13
GALEARIS SPECTABILIS	SHOWY ORCHIS	S2	G5		ST	1962
GENTIANA QUINQUEFOLIA	STIFF GENTIAN	S1SH	G5			1914-09-18
HACKELIA DEFLEXA VAR. AMERICANA	BEGGAR'S-LICE	S1	G5TU		SE	1984-06-02
HACKELIA VIRGINIANA	WOODLAND HOUND'S-TONGUE	S2	G5		ST	1979-08-07
HACKELIA VIRGINIANA	WOODLAND HOUND'S-TONGUE	S2	G5		ST	1963-08-09
HACKELIA VIRGINIANA	WOODLAND HOUND'S-TONGUE	S2	G5		ST	1984-08-02
HYDROPHYLLUM VIRGINIANUM	NORTHERN WATERLEAF	S2	G5		ST	1881-06-04
ISOETES RIPARIA	RIVER BANK QUILLWORT	S2	G4		ST	1891-08-19
PANAX QUINQUEFOLIUM	GINSENG	S2	G4	3C	ST	1917-09-08
POTAMOGETON VASEYI	VASEY'S POND WEED	S2	G3G4		ST	1890-08-19
POTAMOGETON ZOSTERIFORMIS	FLATSTEM PONDWEED	S2	G5		ST	1890-08-19
PRENANTHES SERPENTARIA	GALL-OF-THE-EARTH	SU	G5			1890
SNE MESIC COLLUVIAL SLOPE FOREST						1984-05-22
WALDSTEINIA FRAGARIOIDES	BARREN STRAWBERRY	S1	G5		ST	1962-06-29

NAME	COMNAME	SRANK	GRANK	FED	STATE	LAST OBSERVE
Town of Canaan						
CAREX LENTICULARIS VAR. ALBIMONTANA	LENS SEDGE	S1	G5		ST	1890
Town of Dorchester						
LISTERA CORDATA	HEART-LEAVED TWAYBLADE	S2	G5		ST	1908
Town of Enfield						
ELEOCHARIS ERYTHROPODA	BALD SPIKE-RUSH	SH	G4		ST	1932
AYTHYA COLLARIS	RING-NECKED DUCK	S2	G5			1981
Town of Grantham						
MALAXIS UNIFOLIA	GREEN ADDER'S-MOUTH	S3	G5		ST	1954
NNE ACIDIC ROCKY SUMMIT/ROCK OUTCROP COMMUNITY						1979

Scientific Name	Common Name	SRank	GRank	Federal	State	Last Observed
ACALYPHA VIRGINICA	THREE-SEEDED MERCURY	S2	G3G5		ST	1921-07-22
ACER NIGRUM	BLACK MAPLE	S2SU	G5Q		ST	1980-08
ACHILLEA BOREALIS	NORTHERN YARROW	S2Q	G5			1952-09-20
ADLUMIA FUNGOSA	CLIMBING FUMITORY	S1	G4		ST	1971
AGROSTIS BOREALIS	BOREAL BENTGRASS	S3	G?			1915-07-15
AGROSTIS BOREALIS	BOREAL BENTGRASS	S3	G?			1915-08-10
ALASMIDONTA HETERODON	ANCIENT FLOATER	S1	G1	C2	SE	
ALASMIDONTA HETERODON	ANCIENT FLOATER	S1	G1	C2	SE	
ALASMIDONTA HETERODON	ANCIENT FLOATER	S1	G1	C2	SE	1978-06-15
ALASMIDONTA HETERODON	ANCIENT FLOATER	S1	G1	C2	SE	1973-04-14
ALASMIDONTA HETERODON	ANCIENT FLOATER	S1	G1	C2	SE	1984-06-26
ALASMIDONTA VARICOSA	BROOK FLOATER; SWOLLEN WEDGE-MUSSEL	S1	G3		SE	-
ALLIUM SCHOENOPRASUM VAR. SIBIRICUM	SIBERIAN CHIVES	S2	G5		ST	1983-07-02
ANEMONE CYLINDRICA	THIMBLEWEED	S2SH	G5			1892-08-01
ANEMONE CYLINDRICA	THIMBLEWEED	S2SH	G5			1898-??-??
ARABIS MISSOURIENSIS	MISSOURI ROCK-CRESS	S2	G4G5		ST	1962-07-12
ARABIS MISSOURIENSIS	MISSOURI ROCK-CRESS	S2	G4G5		ST	1986-05-17
ARDEA HERODIAS	GREAT BLUE HERON (ROOKERY)	S3	G5			1986-08-22
ARDEA HERODIAS	GREAT BLUE HERON (ROOKERY)	S3	G5			1987-06-22
ARETHUSA BULBOSA	ARETHUSA	S1	G4		SE	1980-06
ARETHUSA BULBOSA	ARETHUSA	S1	G4		SE	1893-06-10
ARISAEMA DRACONTIUM	GREEN DRAGON	S1	G5		SE	1986-07-18
ASTER CILIOLATUS	CILIATED ASTER	S1	G5		ST	1890-09-10
ASTER CILIOLATUS	CILIATED ASTER	S1	G5		ST	1897-09-03
ASTER CILIOLATUS	CILIATED ASTER	S1	G5		ST	1896-09-25
ASTER CILIOLATUS	CILIATED ASTER	S1	G5		ST	1896-09-28
ASTER CILIOLATUS	CILIATED ASTER	S1	G5		ST	1888-09-15
ASTER CRENIFOLIUS VAR. ARCUANS	LEAFY-BRACTED ASTER	SH	G?		SE	1939-07-29
ASTER PTARMICOIDES	SHOWY ASTER	S1	G5		SE	1984-
AYTHYA COLLARIS	RING-NECKED DUCK	S2	G5			1981-
BARTRAMIA LONGICAUDA	UPLAND SANDPIPER	S2	G5		SE	1987-05-15
BAT HIBERNACULUM	ABANDONED MINE		G5			1987-02-03
BAT HIBERNACULUM	ABANDONED MINE	S1	G5			1988-03-08
BETULA MINOR	SMALL BIRCH	S2	G4G5		SC78	1912-09-12
BETULA MINOR	SMALL BIRCH	S2	G4G5		SC78	1895-10
BROMUS KALMII	KALM'S BROME-GRASS	SH	G5		SE	1876-07-25
BROMUS KALMII	KALM'S BROME-GRASS	SH	G5		SE	1917-08-18
CALAMAGROSTIS CANADENSIS VAR ROBUST	BLUEJOINT	S3			SC78	1915-07-14
CALAMAGROSTIS CANADENSIS VAR ROBUST	BLUEJOINT	S3			SC78	1908-08-03
CALAMAGROSTIS LACUSTRIS	POND REED BENT-GRASS	SU	G3G5		ST	1932
CALAMAGROSTIS LACUSTRIS	POND REED BENT-GRASS	SU	G3G5		ST	1960
CALAMAGROSTIS LACUSTRIS	POND REED BENT-GRASS	SU	G3G5		ST	1915-07-14
CALAMAGROSTIS PICKERINGII	PICKERING'S REED BENT-GRASS	S3	G3		ST	1939-
CALAMAGROSTIS PICKERINGII	PICKERING'S REED BENT-GRASS	S3	G3		ST	1915-07-13
CALYPSO BULBOSA	CALYPSO FAIRY SLIPPER	S1	G5		SE	1893-06
CAMPTOSORUS RHIZOPHYLLUS	WALKING-FERN SPLEENWORT	S1	G5		SE	1876
CAMPTOSORUS RHIZOPHYLLUS	WALKING-FERN SPLEENWORT	S1	G5		SE	1988-06-14
CAMPTOSORUS RHIZOPHYLLUS	WALKING-FERN SPLEENWORT	S1	G5		SE	1952-10-16
CAREX ABDITA	HIDDEN SEDGE	S2	G5		SE	1916-06-01
CAREX AMPHIBOLA VAR. RIGIDA	AMBIGUOUS SEDGE	S2	G5T5		ST	1970-07-15
CAREX AMPHIBOLA VAR. RIGIDA	AMBIGUOUS SEDGE	S2	G5T5		ST	1970-07-15
CAREX AUREA	GOLDEN-FRUITED SEDGE	S2	G5		ST	1892-07-18
CAREX AUREA	GOLDEN-FRUITED SEDGE	S2	G5		ST	1987-06-30
CAREX AUREA	GOLDEN-FRUITED SEDGE	S2	G5		ST	1908-06-08
CAREX AUREA	GOLDEN-FRUITED SEDGE	S2	G5		ST	1944-06-16
CAREX BAILEYI	BAILEY'S SEDGE	S1	G?		ST	1861-08-01
CAREX BEBBII	BEBB SEDGE	S2	G5		ST	1917-07-31
CAREX BEBBII	BEBB SEDGE	S2	G5		ST	1927-07-09

[illegible]	BEBB SEDGE	S2	G5		ST	1969-09-13
CAREX BIGELOWII	BIGELOW'S SEDGE	S3	G5		SC78	1959-
CAREX CAPITATA VAR. ARCTOGENA	HEAD-LIKE SEDGE	S1	G?		ST	1972-09-06
CAREX CASTANEA	CHESTNUT SEDGE	S1	G5		SE	1976-05-25
CAREX CASTANEA	CHESTNUT SEDGE	S1	G5		SE	1984-06-26
CAREX CRISTATELLA	SMALL CRESTED SEDGE	S2	G5			1962-06-29
CAREX CRISTATELLA	SMALL CRESTED SEDGE	S2	G5			1877-06-00
CAREX EBURNEA	EBONY SEDGE	S1	G5		SE	1984-05-22
CAREX GARBERI VAR. BIFARIA	GARBER'S SEDGE	S1	G4T3Q		SE	1984-07-01
CAREX LENTICULARIS VAR ALBIMONTANA	LENS SEDGE	S1	G5T?			1890-07-28
CAREX LENTICULARIS VAR ALBIMONTANA	LENS SEDGE	S1	G5T?			1969-06-20
CAREX LENTICULARIS VAR ALBIMONTANA	LENS SEDGE	S1	G5T?			1893-08-02
CAREX SCIRPOIDEA	SCIRPUS-LIKE SEDGE	S3	G5		ST	1986-06-25
CAREX SCIRPOIDEA	SCIRPUS-LIKE SEDGE	S3	G5		ST	1984-06-07
CAREX SCIRPOIDEA	SCIRPUS-LIKE SEDGE	S3	G5		ST	1915-07-08
CAREX SCIRPOIDEA	SCIRPUS-LIKE SEDGE	S3	G5		ST	1865-08-23
CAREX SPARGANIOIDES	BUR SEDGE	S1	G5		SE	1897-06-04
CAREX WIEGANDII	WIEGAND'S SEDGE	S2	G3?		ST	1967-07-15
CAREX WIEGANDII	WIEGAND'S SEDGE	S2	G3?		ST	1961-08-05
CAREX WIEGANDII	WIEGAND'S SEDGE	S2	G3?		ST	1967-07-15
CELTIS OCCIDENTALIS	HACKBERRY	S2	G5		ST	1986-07-21
CELTIS OCCIDENTALIS	HACKBERRY	S2	G5		ST	1956-06-27
CELTIS OCCIDENTALIS	HACKBERRY	S2	G5		ST	1985-09-12
CHENOPODIUM BOSCIANUM	BOSCIANUM'S PIGWEED	S2	G5			1917-08-18
CIRCUS CYANEUS	NORTHERN HARRIER	S2	G5		ST	1986-
CONVOLVULUS SPITHAMAEUS	LOW BINDWEED	S2	G4G5		ST	1891-06-02
COREGONUS CLUPEAFORMIS	LAKE WHITEFISH	S2	G5			1944
COREGONUS CLUPEAFORMIS	LAKE WHITEFISH	S2	G5			1982
CORYDALIS AUREA	GOLDEN CORYDALIS	SUSX	G5			ND
CORYDALIS AUREA	GOLDEN CORYDALIS	SUSX	G5			1897-06-29
CYNOGLOSSUM BOREALE	HOUND'S-TONGUE	S1SU	G3G4Q		SE	1882-06-22
CYNOGLOSSUM BOREALE	HOUND'S-TONGUE	S1SU	G3G4Q		SE	1886-06-06
CYPERUS ARISTATUS	INCURVED UMBRELLA-SEDGE	S2	G5		ST	1942-08-13
CYPERUS HOUGHTONII	HOUGHTON'S UMBRELLA-SEDGE	S2	G4		ST	1942-08-08
CYPRIPEDIUM ARIETINUM	RAM'S-HEAD LADY'S-SLIPPER	S1	G3	3C	SE	1884-06-07
CYPRIPEDIUM ARIETINUM	RAM'S-HEAD LADY'S-SLIPPER	S1	G3	3C	SE	1887-06-02
CYPRIPEDIUM ARIETINUM	RAM'S-HEAD LADY'S-SLIPPER	S1	G3	3C	SE	1888
CYPRIPEDIUM PARVIFLORUM	SMALL YELLOW LADY'S-SLIPPER	S1	G5?Q		SE	1899-06-03
CYPRIPEDIUM PUBESCENS	LARGE YELLOW LADY'S-SLIPPER	S2	G5		ST	1897-06-03
CYPRIPEDIUM PUBESCENS	LARGE YELLOW LADY'S-SLIPPER	S2	G5		ST	ND
CYPRIPEDIUM PUBESCENS	LARGE YELLOW LADY'S-SLIPPER	S2	G5		ST	1984-06-07
CYPRIPEDIUM PUBESCENS	LARGE YELLOW LADY'S-SLIPPER	S2	G5		ST	1987-09-23
CYPRIPEDIUM REGINAE	SHOWY LADY'S-SLIPPER	S1	G4		SE	1895-06-24
CYPRIPEDIUM REGINAE	SHOWY LADY'S SLIPPER	S1	G4		SE	1987-06-30
CYPRIPEDIUM REGINAE	SHOWY LADY'S SLIPPER	S1	G4		SE	1988-06-14
DENTARIA LACINIATA	CUTLEAF TOOTHWORT	S1	G5		SE	1958-05-17
DENTARIA MAXIMA	GREAT TOOTHWORT	SH	G5Q			1893-05-26
DESCHAMPSIA ATROPURPUREA	MOUNTAIN HAIRGRASS	S2	G5			1935-
DIAPENSIA LAPPONICA	LAPLAND DIAPENSIA	S3	G5		ST	1978-
DICENTRA CANADENSIS	SQUIRREL-CORN	S2	G5		ST	1899-05-09
DICENTRA CANADENSIS	SQUIRREL-CORN	S2	G5		ST	1984-05-22
DICENTRA CANADENSIS	SQUIRREL-CORN	S2	G5		ST	1986-
DIPLAZIUM PYCNOCARPON		S1	G5		SE	1987-09-01
DIPLAZIUM PYCNOCARPON		S1	G5		SE	1947-09-07
DRYOPTERIS FRAGRANS	FRAGRANT FERN	S1	G5		ST	1987-09-01
DRYOPTERIS GOLDIANA	GOLDIE'S FERN	S2	G4		ST	1987-09-01
DRYOPTERIS GOLDIANA	GOLDIE'S FERN	S2	G4		ST	1939-11-26
DRYOPTERIS GOLDIANA	GOLDIE'S FERN	S2	G4		ST	1904-01-02
DRYOPTERIS GOLDIANA	GOLDIE'S FERN	S2	G4		ST	1943-10-10
DRYOPTERIS GOLDIANA	GOLDIE'S FERN	S2	G4		ST	1879-09

ELEOCHARIS ERYTHROPODA	BALD SPIKE-RUSH	SH	G3G5			1932-06-03
EMPETRUM ATROPURPUREUM	PURPLE CROWBERRY	S2	G5?TU			1914-08-24
EMPETRUM NIGRUM	BLACK CROWBERRY	S3	G5		ST	1975-08-0[illegible]
EMPETRUM NIGRUM	BLACK CROWBERRY	S3	G5		ST	1963-06-27
EMPETRUM NIGRUM	BLACK CROWBERRY	S3	G5		ST	1984-06-07
EPILOBIUM CILIATUM	CILIATED WILLOW-HERB	S2	G5		ST	1971-07-17
EPILOBIUM CILIATUM	CILIATED WILLOW-HERB	S2	G5		ST	1891-07-23
EPILOBIUM CILIATUM	CILIATED WILLOW-HERB	S2	G5		ST	1890-09-19
EPILOBIUM CILIATUM	CILIATED WILLOW-HERB	S2	G5		ST	1890-09-22
EPILOBIUM CILIATUM	CILIATED WILLOW-HERB	S2	G5		ST	1985-08-14
EQUISETUM PRATENSE	MEADOW HORSETAIL	S2	G5		ST	1920-06-12
EQUISETUM VARIEGATUM	VARIEGATED HORSETAIL	S2	G5			1980-08-13
EQUISETUM VARIEGATUM	VARIEGATED HORSETAIL	S2	G5			1987-06-30
EQUISETUM VARIEGATUM	VARIEGATED HORSETAIL	S2	G5			1943-05-26
ERAGROSTIS HYPNOIDES	MOSS LOVE-GRASS	SH	G5			1936-08
FALCO PEREGRINUS	PEREGRINE FALCON	S1	G3	LE	SE	1986-
FALCO PEREGRINUS	PEREGRINE FALCON	S1	G3	LE	SE	1927
FALCO PEREGRINUS	PEREGRINE FALCON	S1	G3	LE	SE	1949-04-18
FALCO PEREGRINUS	PEREGRINE FALCON	S1	G3	LE	SE	1949-04-18
FALCO PEREGRINUS	PEREGRINE FALCON	S1	G3	LE	SE	1986-
FALCO PEREGRINUS	PEREGRINE FALCON	S1	G3	LE	SE	1940-07-11
FALCO PEREGRINUS	PEREGRINE FALCON	S1	G3	LE	SE	1940-06-10
FALCO PEREGRINUS	PEREGRINE FALCON	S1	G3	LE	SE	1987-
GALEARIS SPECTABILIS	SHOWY ORCHIS	S2	G5		ST	1962
GALEARIS SPECTABILIS	SHOWY ORCHIS	S2	G5		ST	1908-06-08
GENTIANA ANDREWSII	ANDREW'S GENTIAN	S1	G4		ST	1980-09-21
GENTIANA ANDREWSII	ANDREW'S GENTIAN	S1	G4		ST	1873-08-30
GENTIANA ANDREWSII	ANDREW'S GENTIAN	S1	G4		ST	1888-09-05
GENTIANA CRINITA	FRINGED GENTIAN	S2	G4		ST	1894-09-26
GENTIANA CRINITA	FRINGED GENTIAN	S2	G4		ST	1888-09-25
GENTIANA QUINQUEFOLIA	STIFF GENTIAN	S1SH	G5			1914-09-18
GENTIANA QUINQUEFOLIA	STIFF GENTIAN	S1SH	G5			1886-10-08
GENTIANA QUINQUEFOLIA	STIFF GENTIAN	S1SH	G5			1894-09-26
GENTIANA QUINQUEFOLIA	STIFF GENTIAN	S1SH	G5			1892
GENTIANA QUINQUEFOLIA	STIFF GENTIAN	S1SH	G5			1889-08
GENTIANA QUINQUEFOLIA	STIFF GENTIAN	S1SH	G5			1894-09-09
GEOCAULON LIVIDUM	NORTHERN COMANDRA	S2	G4		ST	1946-07-15
GERANIUM CAROLINIANUM VAR. CONFERTI	CRANESBILL	S1	G5T5?		SE	1959-07-01
GEUM PECKII	MOUNTAIN AVENS	S3	G2	3C	ST	1915-08-10
GEUM PECKII	MOUNTAIN AVENS	S3	G2	3C	ST	1932-07-28
GEUM PECKII	MOUNTAIN AVENS	S3	G2	3C	ST	1984-06-07
GEUM PECKII	MOUNTAIN AVENS	S3	G2	3C	ST	1948-07-26
GEUM PECKII	MOUNTAIN AVENS	S3	G2	3C	ST	1984-06-09
GEUM PECKII	MOUNTAIN AVENS	S3	G2	3C	ST	1986-08-22
HACKELIA DEFLEXA VAR. AMERICANA	BEGGAR'S-LICE	S1	G5TU		SE	1984-08-02
HACKELIA VIRGINIANA	WOODLAND HOUND'S-TONGUE	S2	G5		ST	1979-08-07
HACKELIA VIRGINIANA	WOODLAND HOUND'S-TONGUE	S2	G5		ST	1963-08-09
HACKELIA VIRGINIANA	WOODLAND HOUND'S-TONGUE	S2	G5		ST	1910-07-14
HACKELIA VIRGINIANA	WOODLAND HOUND'S-TONGUE	S2	G5		ST	1984-08-02
HALENIA DEFLEXA	SPURRED GENTIAN	S1	G5		SE	1987-06-30
HEMICARPHA MICRANTHA	SMALL-FLOWERED HEMICARPA	S2	G4			1921
HEMIDACTYLIUM SCUTATUM	FOUR-TOED SALAMANDER	S4	G5			1933-10
HETERANTHERA DUBIA	WATER-STARGRASS	S1	G5		SE	1947-09-11
HYDROPHYLLUM VIRGINIANUM	NORTHERN WATERLEAF	S2	G5		ST	1904-06-05
HYDROPHYLLUM VIRGINIANUM	NORTHERN WATERLEAF	S2	G5		ST	1881-06-04
HYPERICUM PYRAMIDATUM	GREAT ST. JOHN'S-WORT	S2	G4		ST	1958-08-26
INLAND NEW ENGLAND ACIDIC POND SHOR	INLAND NEW ENGLAND ACIDIC POND SHOR					1983-11-07
ISOETES MACROSPORA	LARGE-SPORED QUILLWORT	S1	G5		ST	1871-07-05
ISOETES RIPARIA	RIVER BANK QUILLWORT	S2	G4		ST	1876
ISOETES RIPARIA	RIVER BANK QUILLWORT	S2	G4		ST	1891-08-19

ISOETES RIPARIA	RIVER BANK QUILLWORT	S2	G4		ST	1892-08-01
ISOTRIA MEDEOLOIDES	SMALL WHORLED POGONIA	S2	G2	LE	SE	1924-07-19
JUNIPERUS HORIZONTALIS	CREEPING JUNIPER	S1	G5		SE	1984-05-22
JUNIPERUS HORIZONTALIS	CREEPING JUNIPER	S1	G5		SE	1986-06-25
LIPARIS LOESELII	LOESEL'S TWAYBLADE	S2	G5		ST	1987-06-30
LISTERA CONVALLARIOIDES	LILY-LEAVED TWAYBLADE	S2	G5		ST	1925-08-21
LISTERA CONVALLARIOIDES	LILY-LEAVED TWAYBLADE	S2	G5		ST	1888-08-15
LISTERA CORDATA	HEART-LEAVED TWAYBLADE	S2	G5		ST	1908-06-12
LOBELIA KALMII	KALM'S LOBELIA	S2	G5		ST	1985-08-15
MALAXIS MONOPHYLLOS VAR. BRACHYPODA	WHITE ADDER'S-MOUTH	S1	G5		SE	1880-06-24
MALAXIS UNIFOLIA	GREEN ADDER'S-MOUTH	S3	G5		ST	1925-10-01
MALAXIS UNIFOLIA	GREEN ADDER'S-MOUTH	S3	G5		ST	1949-07-28
MALAXIS UNIFOLIA	GREEN ADDER'S-MOUTH	S3	G5		ST	1938-07-25
MALAXIS UNIFOLIA	GREEN ADDER'S-MOUTH	S3	G5		ST	1891-07-07
MELANERPES ERYTHROCEPHALUS	RED-HEADED WOODPECKER	S1	G5			1984-
MELANERPES ERYTHROCEPHALUS	RED-HEADED WOODPECKER	S1	G5			1970-
MICROTUS CHROTORRHINUS	ROCK VOLE	S4	G5			1950-07-30
MICROTUS CHROTORRHINUS	ROCK VOLE	S4	G5			1950-09-11
MICROTUS CHROTORRHINUS	ROCK VOLE	S4	G5			1936-08-26
MILIUM EFFUSUM	MILLET-GRASS	S2	G5		ST	1948-07-23
MILIUM EFFUSUM	MILLET-GRASS	S2	G5		ST	1969-07-02
MILIUM EFFUSUM	MILLET-GRASS	S2	G5		ST	1948-07-23
MINUARTIA GLABRA	SMOOTH SANDWORT	S2	G4G5Q		ST	1980
MINUARTIA GROENLANDICA	MOUNTAIN SANDWORT	S4	G5			1915-07-17
MINUARTIA GROENLANDICA	MOUNTAIN SANDWORT	S4	G5			1980-09-06
MINUARTIA STRICTA	ROCK SANDWORT	S1	G5		SE	1953-06-31
NE ALPINE COMMUNITY						1982
NE ALPINE COMMUNITY						1971
NE CALCAREOUS RIVERSIDE SEEP COMMUN						1985-06-03
NNE ACIDIC LEVEL FEN						1984-06-07
NNE ACIDIC ROCKY SUMMIT/ROCK OUTCRO						1971
NNE ACIDIC ROCKY SUMMIT/ROCK OUTCRO						1986-09-05
NNE ACIDIC SEEPAGE SWAMP						1984-05-22
NNE CALCAREOUS CLIFF COMMUNITY		S2				1984
NNE CALCAREOUS CLIFF COMMUNITY						1984-05-22
NNE CALCAREOUS CLIFF COMMUNITY		S1				1986-06-25
NNE CALCAREOUS ROCKY SUMMIT/ROCK OU						1983-10-20
NNE CALCAREOUS SLOPING FEN						1984-07-01
NNE CIRCUMNEUTRAL CLIFF COMMUNITY						1986-04-26
NNE COLD-AIR TALUS FOREST/WOODLAND						1984-06-07
NNE FLOODPLAIN FOREST						1985-09-12
NNE HIGH ELEVATION SPRUCE FIR FORES						1973
NNE HIGH ELEVATION SPRUCE FIR FORES						1986-10-03
NNE LEVEL BOG						1984-05-22
NNE MESIC COLLUVIAL SLOPE FOREST						1971
NNE MESIC COLLUVIAL SLOPE FOREST						1983-10-20
NNE MESIC COLLUVIAL SLOPE FOREST						1985-06-13
NNE MESIC COLLUVIAL SLOPE FOREST						1986-06-25
NNE MESIC HARDWOOD FOREST ON ACIDIC						1973
NNE MESIC HARDWOOD FOREST ON ACIDIC						1971
NNE MESIC HARDWOOD FOREST ON ACIDIC						1972-
NNE RIVERSIDE OUTCROP COMMUNITY						1983-10-21
NNE SEEPAGE FOREST						1987-09-23
NUPHAR ADVENA	SPATTER-DOCK	S2	G5			1910-07-12
ORYZOPSIS CANADENSIS	CANADIAN MOUNTAIN-RICE	SH	G5		SE	1966-
PANAX QUINQUEFOLIUM	GINSENG	S2	G4	3C	ST	1987-09-01
PANAX QUINQUEFOLIUM	GINSENG	S2	G4	3C	ST	1913-09
PANAX QUINQUEFOLIUM	GINSENG	S2	G4	3C	ST	1899-08-25
PANAX QUINQUEFOLIUM	GINSENG	S2	G4	3C	ST	1910-07-28
PANAX QUINQUEFOLIUM	GINSENG	S2	G4	3C	ST	1917-09-08

PANAX QUINQUEFOLIUM	GINSENG	S2	G4	3C	ST	[illegible]
PANAX QUINQUEFOLIUM	GINSENG	S2	G4	3C	ST	1986-07-21
PARNASSIA GLAUCA	GRASS-OF-PARNASSUS	S2	G5		ST	1985-08-16
PARNASSIA GLAUCA	GRASS-OF-PARNASSUS	S2	G5		ST	1984-06-26
PARNASSIA GLAUCA	GRASS-OF-PARNASSUS	S2	G5		ST	1987-06-30
PARONYCHIA ARGYROCOMA VAR. ALBIMONT	SILVERLING	S3	G4	3B	ST	1924
PARONYCHIA ARGYROCOMA VAR. ALBIMONT	SILVERLING	S3	G4	3B	ST	1954-[illegible]
PARONYCHIA ARGYROCOMA VAR. ALBIMONT	SILVERLING	S3	G4	3B	ST	1977-07-03
PARONYCHIA ARGYROCOMA VAR. ALBIMONT	SILVERLING	S3	G4	3B	ST	1979
PARONYCHIA ARGYROCOMA VAR. ALBIMONT	SILVERLING	S3	G4	3B	ST	?
PICOIDES TRIDACTYLUS	THREE-TOED WOODPECKER	S1	G5			1980-07-10
PICOIDES TRIDACTYLUS	THREE-TOED WOODPECKER	S1	G5			1983-08-07
PINGUICULA VULGARIS	BUTTERWORT	S1	G5		SE	1984-06-07
PINUS BANKSIANA	JACK PINE	S2	G5		ST	1978-07-16
PODILYMBUS PODICEPS	PIED-BILLED GREBE	S2	G5		SE	1985-
POLYGONUM DOUGLASII	DOUGLAS KNOTWEED	S2	G5		ST	1964-09-10
POTAMOGETON ALPINUS	THIN-LEAVED ALPINE PONDWEED	S2	G5		ST	1910-07-12
POTAMOGETON FILIFORMIS VAR ALPINUS	NORTHERN SLENDER PONDWEED	S1	G4G5			ND
POTAMOGETON NODOSUS	KNOTTY PONDWEED	S2	G5			1876-08-17
POTAMOGETON PECTINATUS	SAGO PONDWEED	S2	G5		ST	1948-07-27
POTAMOGETON PECTINATUS	SAGO PONDWEED	S2	G5			1948-07-27
POTAMOGETON PRAELONGUS	PROLONGED PONDWEED	S2	G5			1887-06-18
POTAMOGETON VASEYI	VASEY'S POND WEED	S2	G3G4		ST	1890-08-19
POTAMOGETON ZOSTERIFORMIS	FLATSTEM PONDWEED	S2	G5		ST	1890-08-19
POTENTILLA ROBBINSIANA	ROBBIN'S CINQUEFOIL	S1	G1	LE	SE	1984-06
PRENANTHES SERPENTARIA	GALL-OF-THE-EARTH	SU	G5			1890
PROSOPIUM CYLINDRACEUM	ROUND WHITEFISH	S1	G5			1982
PYROLA ASARIFOLIA	BOG WINTERGREEN	S2	G5		SE	1876
QUERCUS MACROCARPA	MOSSY-CUP OAK	SU	G5			1959-05
SALIX HERBACEA	DWARF WILLOW	S2	G5		ST	1915-08-11
SALMO SALAR	ATLANTIC SALMON	S2	G5			1938-07-18
SALMO SALAR	ATLANTIC SALMON	S2	G5			1938
SALMO SALAR	ATLANTIC SALMON	S2	G5			1938-07-27
SALMO SALAR	ATLANTIC SALMON	S2	G5			1938-07-13
SANICULA GREGARIA	GREGARIOUS BLACK SNAKEROOT	S2	G?		ST	1940-08-02
SANICULA GREGARIA	GREGARIOUS BLACK SNAKEROOT	S2	G?		ST	1942-08-13
SANICULA GREGARIA	GREGARIOUS BLACK SNAKEROOT	S2	G?		ST	1943-06-18
SANICULA GREGARIA	GREGARIOUS BLACK SNAKEROOT	S2	G?		ST	1939-07-29
SANICULA TRIFOLIATA	THREE-LEAVED BLACK SNAKEROOT	S2	G3G5		ST	1940-07-25
SCIRPUS POLYPHYLLUS	MANY LEAVED BULRUSH	S1SU	G5		SE	1948-09-01
SENECIO PAUPERCULUS	DWARF RAGWORT	S2	G5		ST	1987-06-30
SENECIO PAUPERCULUS	DWARF RAGWORT	S2	G5		ST	1983-10-21
SENECIO PAUPERCULUS	DWARF RAGWORT	S2	G5		ST	1983-07-02
SNE CIRCUMNEUTRAL ROCKY SUMMIT/ROCK						1971
SNE CIRCUMNEUTRAL TALUS FOREST/WOOD						1986-05-17
SNE FLOODPLAIN FOREST						1986-07-21
SNE LAKE SEDIMENT/RIVER TERRACE FOR						1986-07-21
SNE MESIC COLLUVIAL SLOPE FOREST						1984-05-22
SOLIDAGO CUTLERI	ALPINE GOLDENROD	S3	G4		ST	1975-08-02
SOLIDAGO ODORA	SWEET GOLDENROD	S2	G5		ST	1980-10-09
SOLIDAGO PURSHII	PURSH'S GOLDENROD	S1	G5		ST	1962-09-06
SOLIDAGO PURSHII	PURSH'S GOLDENROD	S1	G5		ST	1984-06-07
SOLIDAGO PURSHII	PURSH'S GOLDENROD	S1	G5		ST	1884-08-25
SOLIDAGO PURSHII	PURSH'S GOLDENROD	S1	G5		ST	1934-08-25
SOLIDAGO PURSHII	PURSH'S GOLDENROD	S1	G5		ST	1932-08-26
SOREX DISPAR	LONG-TAILED OR ROCK SHREW	S4	G5	C2		1927-08-22
SOREX DISPAR	LONG-TAILED OR ROCK SHREW	S4	G5	C2		1950
SOREX DISPAR	LONG-TAILED OR ROCK SHREW	S4	G5	C2		1957-10-06
SPIRANTHES LUCIDA	SHINING LADY'S-TRESSES	S1	G5		ST	1984-07-01
SPOROBOLUS NEGLECTUS	SMALL DROP-SEED	S1	G?		SE	1983-10-21

SYNAPTOMYS BOREALIS	NORTHERN BOG LEMMING	S1	G5	SE	1958-10-11
TEUCRIUM CANADENSE VAR. VIRGINICUM	CANADIAN GERMANDER	S2	G5TU	SE	1892
TEUCRIUM CANADENSE VAR. VIRGINICUM	CANADIAN GERMANDER	S2	G5TU	SE	1892
TOFIELDIA GLUTINOSA	STICKY FALSE ASPHODEL	S1	G5	ST	1987-06-30
TRIPHORA TRIANTHOPHORA	THREE-BIRDS ORCHID	S2	G4	ST	1987-10-15
TRISETUM MELICOIDES	BRISTLE GRASS	SH	G?		1882-08-08
UVULARIA GRANDIFLORA	LARGE-FLOWERED BELLWORT	S1	G5	SE	1904-05-07
VACCINIUM BOREALE	BOREAL BLUEBERRY	S3	G3		1915-09-04
VACCINIUM ULIGINOSUM VAR. ALPINUM	BILBERRY	S3	G5	ST	1975-08-01
VACCINIUM VITIS-IDAEA VAR. MINUS	MOUNTAIN CRANBERRY	S4	G5		1962-09-30
VERMIVORA PEREGRINA	TENNESSEE WARBLER	S2	G5		1987-05-15
WALDSTEINIA FRAGARIOIDES	BARREN STRAWBERRY	S1	G5	ST	1962-06-29
WALDSTEINIA FRAGARIOIDES	BARREN STRAWBERRY	S1	G5	ST	1965-05-17
WALDSTEINIA FRAGARIOIDES	BARREN STRAWBERRY	S1	G5	ST	1984-06
WOODSIA GLABELLA	SMOOTH WOODSIA	S1	G5	SE	1984-05-22
WOODSIA GLABELLA	SMOOTH WOODSIA	S1	G5	SE	1871-07
WOODSIA OBTUSA	BLUNT-LOBE WOODSIA	S2	G5	ST	1894-06-20

Sullivan County

Scientific Name	Common Name	SRank	GRank	Federal	State	Last Observed
ACER NIGRUM	BLACK MAPLE	S2SU	G5Q		ST	1971-10-02
ADLUMIA FUNGOSA	CLIMBING FUMITORY	S1	G4		ST	1984-06-25
ALASMIDONTA HETERODON	DWARF WEDGE MUSSEL	S1	G1	C2	SE	1988-09-12
ALASMIDONTA HETERODON	DWARF-WEDGE MUSSEL	S1	G1	C2	SE	1984-08-06
ALLIUM SCHOENOPRASUM VAR. SIBIRICUM	SIBERIAN CHIVES	S2	G5		ST	1956-06-28
ALLIUM SCHOENOPRASUM VAR. SIBIRICUM	SIBERIAN CHIVES	S2	G5		ST	1985-06-21
AMPHICARPAEA BRACTEATA VAR. COMOSA	HOG-PEANUT	S2	G5T?		ST	1963-08-22
ARDEA HERODIAS	GREAT BLUE HERON (ROOKERY)	S3	G5			1986-09-01
ARISAEMA DRACONTIUM	GREEN DRAGON	S1	G5		SE	1985-
ASCLEPIAS QUADRIFOLIA	FOUR-LEAVED MILKWEED	S2	G5		ST	1956-06-28
ASTRAGALUS ALPINUS VAR. BRUNETIANUS	ALPINE MILK-VETCH	S1	G5T1			1894-06-28
ASTRAGALUS ROBBINSII VAR. JESUPI	ROBBINS' MILK-VETCH	S1	G4T1	LE	SE	1985-06-03
ASTRAGALUS ROBBINSII VAR. JESUPI	ROBBINS' MILK-VETCH	S1	G4T1	LE	SE	1987-08-18
CALLITRICHE ANCEPS	NORTHERN WATER-STARWORT	SH	G5			1899-09-15
CAMPANULA ULIGINOSA	GREATER MARSH-BELLFLOWER	S1	G5			1935-07-21
CAMPTOSORUS RHIZOPHYLLUS	WALKING-FERN SPLEENWORT	S1	G5		SE	1881-08-21
CAREX AMPHIBOLA VAR. RIGIDA	AMBIGUOUS SEDGE	S2	G5T5		ST	1932-06-18
CAREX AMPHIBOLA VAR. RIGIDA	AMBIGUOUS SEDGE	S2	G5T5		ST	1984-06-25
CAREX AUREA	GOLDEN-FRUITED SEDGE	S2	G5		ST	1981
CAREX CRISTATELLA	SMALL CRESTED SEDGE	S2	G5			1960
CAREX GARBERI VAR. BIFARIA	GARBER'S SEDGE	S1	G4T3Q		SE	1984-06-12
CAREX GARBERI VAR. BIFARIA	GARBER'S SEDGE	S1	G4T3Q		SE	1985-06-21
CAREX GRANULARIS VAR. HALEANA	GRANULAR SEDGE	SH	G5T3?		SE	1985-06-21
CELTIS OCCIDENTALIS	HACKBERRY	S2	G5		ST	1985-07-17
CELTIS OCCIDENTALIS	HACKBERRY	S2	G5		ST	1955-07-13
CELTIS OCCIDENTALIS	HACKBERRY	S2	G5		ST	1970-07-22
CICINDELA MARGINIPENNIS	COBBLESTONE TIGER BEETLE	S1	G2G3	C2	ST	1984-07-17
CICINDELA MARGINIPENNIS	COBBLESTONE TIGER BEETLE	S1	G2G3	C2	ST	1984-07-31
CICINDELA MARGINIPENNIS	COBBLESTONE TIGER BEETLE	S1	G2G3	C2	ST	1984-07-25
CORALLORHIZA ODONTORHIZA	AUTUMN CORAL-ROOT	S1SH	G5		SE	1922
CRYPTOGRAMMA STELLERI	SLENDER CLIFF-BRAKE	S1	G5		ST	1984-06-25
CRYPTOGRAMMA STELLERI	SLENDER CLIFF-BRAKE	S1	G5		ST	1983-07-02
CYPRIPEDIUM ARIETINUM	RAM'S-HEAD LADY'S-SLIPPER	S1	G3	3C	SE	1888
CYPRIPEDIUM PARVIFLORUM	SMALL YELLOW LADY'S-SLIPPER	S1	G5?Q		SE	ND
DENTARIA LACINIATA	CUTLEAF TOOTHWORT	S1	G5		SE	1985-
DICENTRA CANADENSIS	SQUIRREL-CORN	S2	G5		ST	1918-05-17
DICENTRA CANADENSIS	SQUIRREL-CORN	S2	G5		ST	1889-05-04
DICENTRA CANADENSIS	SQUIRREL-CORN	S2	G5		ST	1985-05-15
DRYOPTERIS GOLDIANA	GOLDIE'S FERN	S2	G4		ST	1984-06-25
ELEOCHARIS ERYTHROPODA	BALD SPIKE-RUSH	SH	G3G5			1893
ELEOCHARIS PAUCIFLORA VAR. FERNALDI	FEW-FLOWERED SPIKE-RUSH	S2	G5Q			1960-07-12
ELEOCHARIS PAUCIFLORA VAR. FERNALDI	FEW-FLOWERED SPIKE-RUSH	S2	G5Q			1960-07-12
EPILOBIUM CILIATUM	CILIATED WILLOW-HERB	S2	G5		ST	1971-08-22
EQUISETUM PALUSTRE	MARSH HORSETAIL	S1	G5		ST	1984-06-25
EQUISETUM PRATENSE	MEADOW HORSETAIL	S2	G5		ST	1984-06-25
EQUISETUM VARIEGATUM	VARIEGATED HORSETAIL	S2	G5			1985-06-21
GALEARIS SPECTABILIS	SHOWY ORCHIS	S2	G5		ST	1982
HACKELIA VIRGINIANA	WOODLAND HOUND'S-TONGUE	S2	G5		ST	1963-08-23
HACKELIA VIRGINIANA	WOODLAND HOUND'S-TONGUE	S2	G5		ST	1962-08-09
HIPPURIS VULGARIS	COMMON MARE'S-TAIL	S3	G5		ST	1928-10-04
HYDROPHYLLUM VIRGINIANUM	NORTHERN WATERLEAF	S2	G5		ST	1983-07-02
HYDROPHYLLUM VIRGINIANUM	NORTHERN WATERLEAF	S2	G5		ST	1957-06-22
HYDROPHYLLUM VIRGINIANUM	NORTHERN WATERLEAF	S2	G5		ST	1979-06-20
HYPERICUM PYRAMIDATUM	GREAT ST. JOHN'S-WORT	S2	G4		ST	1985-07-24
HYPERICUM PYRAMIDATUM	GREAT ST. JOHN'S-WORT	S2	G4		ST	1984-08-30
LEPTOLOMA COGNATUM	FALL WITCH-GRASS	S3	G5			1983-10-03
LIPARIS LOESELII	LOESEL'S TWAYBLADE	S2	G5		ST	1984-08-03
LIPARIS LOESELII	LOESEL'S TWAYBLADE	S2	G5		ST	1985-06-21

LOBELIA KALMII	KALM'S LOBELIA	S2	G5		ST	1985-06-21
MALAXIS UNIFOLIA	GREEN ADDER'S-MOUTH	S3	G5		ST	1954-09-26
MIMULUS MOSCHATUS	MUSKFLOWER	S1	G4G5		SE	1984-06-25
MIMULUS MOSCHATUS	MUSKFLOWER	S1	G4G5		SE	1984-06-12
MIMULUS MOSCHATUS	MUSKFLOWER	S1	G4G5		SE	1985-06-30
MYRIOPHYLLUM FARWELLII VAR. AMERICA	FARWELL'S MILFOIL	S2	G5		ST	1928-10-04
NE CALCAREOUS RIVERSIDE SEEP COMMUN						1983-10-13
NE CALCAREOUS RIVERSIDE SEEP COMMUN						1984-08-30
NNE ACIDIC ROCKY SUMMIT/ROCK OUTCRO						1979-
NNE FLOODPLAIN FOREST						1985-07-17
NNE FLOODPLAIN FOREST						1985-07-18
NNE MESIC COLLUVIAL SLOPE FOREST						1982
PANAX QUINQUEFOLIUM	GINSENG	S2	G4	3C	ST	ND -
PANAX QUINQUEFOLIUM	GINSENG	S2	G4	3C	ST	1984-08-03
PARNASSIA GLAUCA	GRASS-OF-PARNASSUS	S2	G5		ST	1985-06-21
PARNASSIA GLAUCA	GRASS-OF-PARNASSUS	S2	G5		ST	1984-06-12
POLIOPTILA CAERULEA	BLUE-GRAY GNATCATCHER	S2	G5			1984-
POTAMOGETON NODOSUS	KNOTTY PONDWEED	S2	G5			1981-07-06
POTAMOGETON NODOSUS	KNOTTY PONDWEED	S2	G5			1947-08-07
POTAMOGETON PECTINATUS	SAGO PONDWEED	S2	G5		ST	1972-07-24
POTAMOGETON VASEYI	VASEY'S PONDWEED	S2	G3G4		ST	1972-07-24
RHYNCHOSPORA CAPILLACEA	HAIR-LIKE BEAK-RUSH	S1	G5		SE	1984-06-12
ROSA ACICULARIS	PRICKLEY ROSE	S1	G5		SE	1955-07-13
SALIX CORDATA VAR ABRASA	HEART SHAPED WILLOW	S1	G5			1956-06-27
SALIX CORDATA VAR ABRASA	HEART SHAPED WILLOW	S1	G5			1985-06-21
SANICULA GREGARIA	GREGARIOUS BLACK SNAKEROOT	S2	G?		ST	1899-09-15
SANICULA TRIFOLIATA	THREE-LEAVED BLACK SNAKEROOT	S2	G3G5		ST	1906
SANICULA TRIFOLIATA	THREE-LEAVED BLACK SNAKEROOT	S2	G3G5		ST	1984-08-03
SCIRPUS PENDULUS	LINED BULRUSH	S2	G5		ST	1982-07-01
SCIRPUS POLYPHYLLUS	MANY LEAVED BULRUSH	SU	G5		SE	1876-
SENECIO PAUPERCULUS	DWARF RAGWORT	S2	G5		ST	1985-06-03
SENECIO PAUPERCULUS	DWARF RAGWORT	S2	G5		ST	1984-06-26
SENECIO PAUPERCULUS	DWARF RAGWORT	S2	G5		ST	1985-
SNE CIRCUMNEUTRAL ROCKY SUMMIT/ROCK						1985-09-25
SNE FLOODPLAIN FOREST						1984-06-24
SNE FLOODPLAIN FOREST						1985-07-17
SNE MESIC COLLUVIAL SLOPE FOREST						1984-06-25
SNE MESIC COLLUVIAL SLOPE FOREST						1983-07-02
SNE RIVERSIDE OUTCROP COMMUNITY						1986-07-09
SPIRANTHES LUCIDA	SHINING LADY'S-TRESSES	S1	G5		ST	1985-06-03
SPIRANTHES LUCIDA	SHINING LADY'S-TRESSES	S1	G5		ST	1984-06-26
SPIRANTHES LUCIDA	SHINING LADY'S-TRESSES	S1	G5		ST	1985-06-21
STAPHYLEA TRIFOLIA	BLADDERNUT	S3	G5		ST	1984-06-25
TEUCRIUM CANADENSE VAR. VIRGINICUM	CANADIAN GERMANDER	S2	G5TU		SE	1931-09-07
TOFIELDIA GLUTINOSA	STICKY FALSE ASPHODEL	S1	G5		ST	1984-06-12
TOFIELDIA GLUTINOSA	STICKY FALSE ASPHODEL	S1	G5		ST	1985-06-21
UVULARIA GRANDIFLORA	LARGE-FLOWERED BELLWORT	S1	G5		SE	1985-
UVULARIA GRANDIFLORA	LARGE-FLOWERED BELLWORT	S1	G5		SE	1979-06-11
VIOLA AFFINIS	PALE EARLY VIOLET	S2	G5		SE	1902
WALDSTEINIA FRAGARIOIDES	BARREN STRAWBERRY	S1	G5		ST	1940-05-19
WOODSIA OBTUSA	BLUNT-LOBE WOODSIA	S2	G5		ST	1898-06-27
WOODSIA OBTUSA	BLUNT-LOBE WOODSIA	S2	G5		ST	1900-07-31

THE RANKING SYSTEM DEVELOPED BY THE NATURE CONSERVANCY AND USED BY ALL STATE NATURAL HERITAGE PROGRAMS FOR "ELEMENTS" OF NATURAL DIVERSITY (RARE SPECIES AND EXEMPLARY NATURAL COMMUNITIES)

Each element is assigned a single global rank by specialists under the guidance of the national Science Department of The Nature Conservancy. State ranks within each state, in which the element occurs, are assigned by the state Heritage Program and will vary from state to state.

GLOBAL ELEMENT RANKS:

G1 = Critically imperiled globally because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres) or because of some factor of its biology making it especially vulnerable to extinction. [Critically endangered throughout range.]

G2 = Imperiled globally because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of other factors demonstrably making it very vulnerable to extinction throughout its range. [Endangered throughout range.]

G3 = Either very rare and local throughout its range or found locally (even abundantly at some of its locations) in a restricted range (e.g., a single state, a physiographic region) or because of other factors making it vulnerable to extinction throughout its range; in terms of occurrences, in the range of 21 to 100. [Threatened throughout range].

G4 = Apparently secure globally, though it may be quite rare in parts of its range, especially at the periphery.

G5 = Demonstrably secure globally, though it may be quite rare in parts of its range, especially at the periphery.

GA = Accidental in North America (not part of the established biota, usually a species of bird).

GE = An exotic species established in North America (e.g., Japanese Honeysuckle).

GH = Of historical occurrence throughout its range, i.e. formerly part of the established biota, with the expectation that it may be rediscovered (e.g., Ivory-billed Woodpecker).

The New Hampshire Natural Heritage Inventory does not inventory GA or GE species.

Key to Status

NH Native Plant Protection Act: RSA 217-A:3,III (endangered plants) and RSA 217-A:3,XII (threatened plants). State protected animals: Fish & Game Rules Chapt. Fis 1000 Conservation of Endangered Species. Part Fis 1001.01 (endangered animals) and 1001.02 (threatened animals).

SE = State Endangered
ST = State Threatened

Federal Endangered Species Act, 1973. Public Law 93-205, as amended.

FE = Federally Endangered
FT = Federally Threatened
FC = Federal Candidate Species (includes 3C, C2, etc.)

STATE ELEMENT RANKS:

- S1 = Critically imperiled in state because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres) or because of some factor of its biology making it especially vulnerable to extirpation from the state. [Critically endangered in state.]
- S2 = Imperiled in state because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of other factors demonstrably making it very vulnerable to extirpation from the state. [Endangered in state].
- S3 = Rare in state (on the order of 20+ occurrences). [Threatened in state].
- S4 = Apparently secure in state.
- S5 = Demonstrably secure in state.
- SA = Accidental in state, including species which only sporadically breed in state.
- SE = An exotic species established in state; may be native elsewhere in North America (e.g., house finch).
- SH = Of historical occurrence in the state with the expectation that it may be rediscovered.
- SU = Possibly in peril in state but status uncertain; need more information.
- SX = Apparently extirpated from state.

The New Hampshire Natural Heritage Inventory primarily inventories elements in the S1 and S2 categories plus several selected elements ranked S3.